Appendix 7-E

SLOPE STABILITY ANALYSIS

SEDIMENTATION POND "A"

SLOPE STABILITY ANALYSIS
ON
EMBANKMENT OF SEDIMENTATION POND "A"
BEAR CREEK CANYON MINE SITE
CO-OP MINING COMPANY

JULY 1984

Prepared by

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SECTION 1

In conjunction with the redesign of sedimentation pond "A" of the Bear Creek Canyon Mine site, various in place and laboratory soil tests were performed. Using the parameters obtained from these tests, slope stability analysis were performed to confirm the stability of the 2H:IV interior slope and determine a stable angle for the exterior slope.

SECTION II CONSTRUCTION

On September 29, 1983, I visited the site in conjunction with Wendell Owen of the Co-Op and reviewed in detail the provisions taken at the site during construction. I also reviewed with Mr. Owen the construction procedures which enabled me to determine how the embankment was constructed to its present slope.

SECTION III MATERIAL TESTING

While at the site, using a Troxler 3411B nuclear density gauge, I determined the in-place density of the embankment material. I also obtained moisture density samples and samples of the embankment material, which I returned to the lab for additional testing. The results of these in-place determinations indicate that the average in-place density of the material varied from 89% to 94% of the laboratory obtained T-99 standard proctor.

I submitted a sample of the embankment material to Chen and Associates, a consulting soil and foundation engineering firm, to determine the relationship of the loading to shear stress, and to determine the internal cohesion. These results are included in the Appendix. The material gradation results are also included in the Appendix. The gradation results indicated that the material is free draining confirming the on site tests.

SECTION IV OCCURRENCE OF GROUND WATER

The results of the gradation analysis indicate that the material is free draining. This was further observed at the site through reviewing the existing material in place and performing percolation tests in the embankment. Because of the geology of the mine plan area the embankment is not effected by ground water, but for purposes of analysis the soil was assumed saturated by the water occasionally held in the pond. This assumed extent of saturation provides for conservative results.

SECTION V FACTOR OF SAFETY

A computer model was constructed to analyze the stability of the embankment and the following conditions were assumed.

1. The soil below the maximum water elevation on the interior slope to the toe of the exterior slope (soil #2) was assumed saturated.

2. In-place soil density of 118 pounds per cubic foot.

3 2H:IV angles were used for both interior and exterior slopes.

A computer simulation was then applied to this situation to determine various failure planes. The "Method of Slices" is the basis for the modified Bishop method computer program. Various failure planes were investigated to determine a minimum factor of safety. The results of these computer runs and a copy of the computer listing is attached in the Appendix. The results of these computer simulations indicate that the minimum factor of safety with a .1 g earthquake loading is 3.8 for the interior slope and 2.8 for the exterior slope at the point of maximum length.

SECTION VI CONCLUSIONS

In conclusion the sedimentation pond "A" embankment as now existing is:

1. Free draining.

2. No water was encountered in test holes dug in embankments.

3. No movement of the embankment has been detected.

4. The computer simulation on failure planes indicates that the factor of safety is at least 2.8 with a 0.1 g earthquake loading for 2H:IV slopes for both the interior and exterior of the embankment.

APPENDIX

ENGINEERS

Project Name Lime Mine Date 10/6/82

Project No. _____ Station or Pit Location _____

Sample No #2 Requisted by +CW

2 Native material, Pond dikes

AS RECEIVED GRADATION

Screen Size	Weight (a)	Percent Retained	Percent Passing	SPECS.
3"				
2"	0	0	100%	
1 1/2"	1132.1	14.0	86.0	
3/4"	875.5	10.9	75.1	
1/2"	466.3	5.8	69.3	
3/8"				
#4	1112.1	13.8	55.6	
Wet Wt. #4				
Dry Wt. #	4481	55.6		
Total Wt Dry	8059.1			

WASHED GRADATION AFTER CRUSHING (2500 GM. DRY SAMPLE)

Screen Size	Weight Retained	Percent Retained	Percent Passing	Total % Passing	SPECS.
#8	141.7	8.9	91.1	19.7	
#10	31.1	2.0	89.1	17.9	
#16	69.5	4.4	84.7	17.5	
#20	40.7	2.6	82.2	16.7	
#30	31.8	2.0	80.1	16.2	
#40	47.9	3.0	77.1	15.8	
#50	91.4	5.9	71.4	15.2	
#100	350.2	22.1	49.3	14.0	
Pan	146.6	9.2	40.1	9.7	
#200	635.7	40.1	0		
Total Wt	15868				

MOISTURE DETERMINATION

	-#4
Container & Wet Soil Weight (gm.)	
Container & Dry Soil Weight (gm.)	
H_2O Loss	
% Moisture	

A.A.S.H.O Classification

Wt. before washing _____

Wt. after washing _____

COPIES TO:

Tested by KARL I. [illegible]

F"H ENGINEERS

Project Name: Coal Mine Date: 10/6/8-
Project No.: ______ Station or Pit Location: ______
Sample No: #1 [illegible] Requisted by: [illegible]
~ Sediment in Pond

AS RECEIVED GRADATION

Screen Size	Weight (g)	Percent Retained	Percent Passing	SPECS.
3"				
2"				
1"	0	0	100%	
3/4"	63.0	0.8	99.2	
1/2"	[illegible]	1.2	[illegible]	
~~3/8"~~				
#4	[illegible]	3.9	94.1	
~~Wet Wt. -#4~~				
Dry Wt -#4	7654.4	94.		
Total Wt Dry	8131.9			

WASHED GRADATION AFTER CRUSHING (2500 GM. DRY SAMPLE)

Screen Size	Weight Retained	Percent Retained	Percent Passing	Total % Passing	SPECS.
#8	126.3	8.5	91.5	18.3	
#10	37.6	2.5	89.0	16.8	
#16	121.7	8.2	80.8	16.3	
#20	79.7	5.4	75.5	14.8	
#30	60.4	4.1	71.4	13.8	
#40	67.1	4.5	66.9	13.1	
#50	95.5	6.4	60.5	12.3	
#100	[illegible]	22.[illegible]	38.4	11.1	
#200	112.[illegible]	7.6	30.5	7.0	
-#200	457.0	30.8	0		
Total Wt	1487.1				

Wt. before washing ______
Wt. after washing ______

MOISTURE DETERMINATION	-#4
Container & Wet Soil Weight (gm.)	
Container & Dry Soil Weight (gm.)	
H_2O Loss	
% Moisture	

A.A.S.H.O Classification

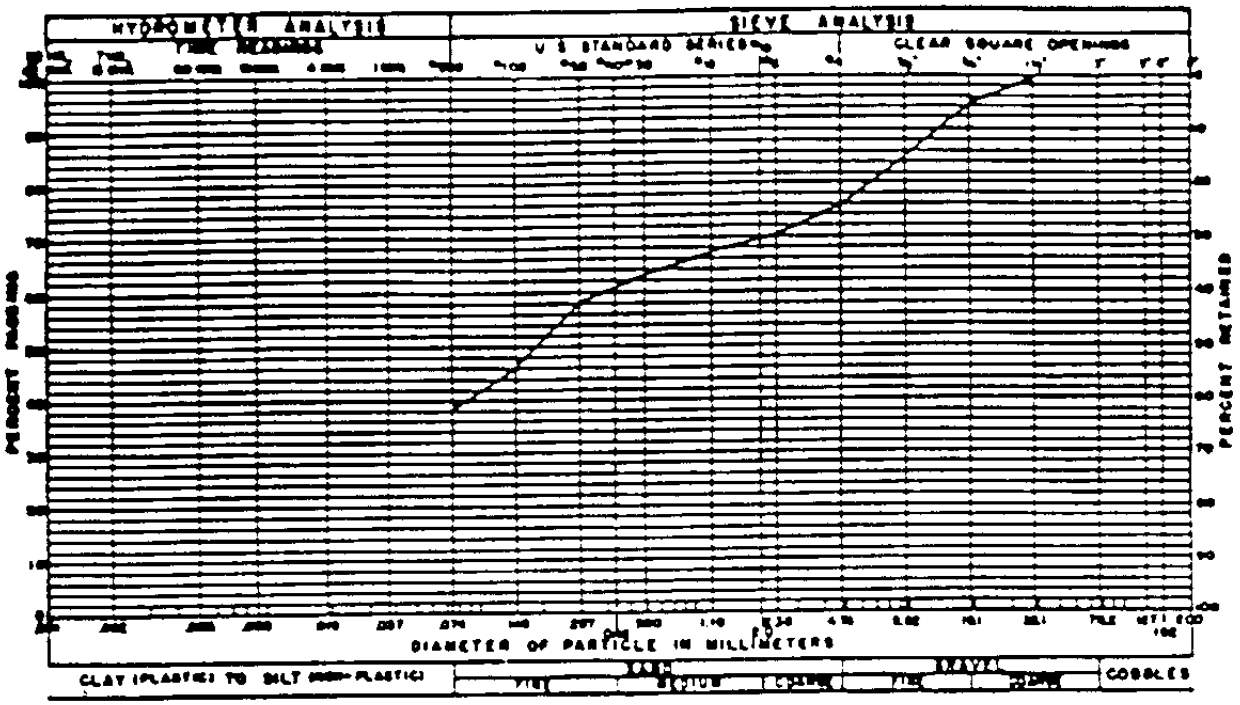
COPIES TO:

Tested by: Kirk [illegible]

CHEN AND ASSOCIATES

Consulting Engineers

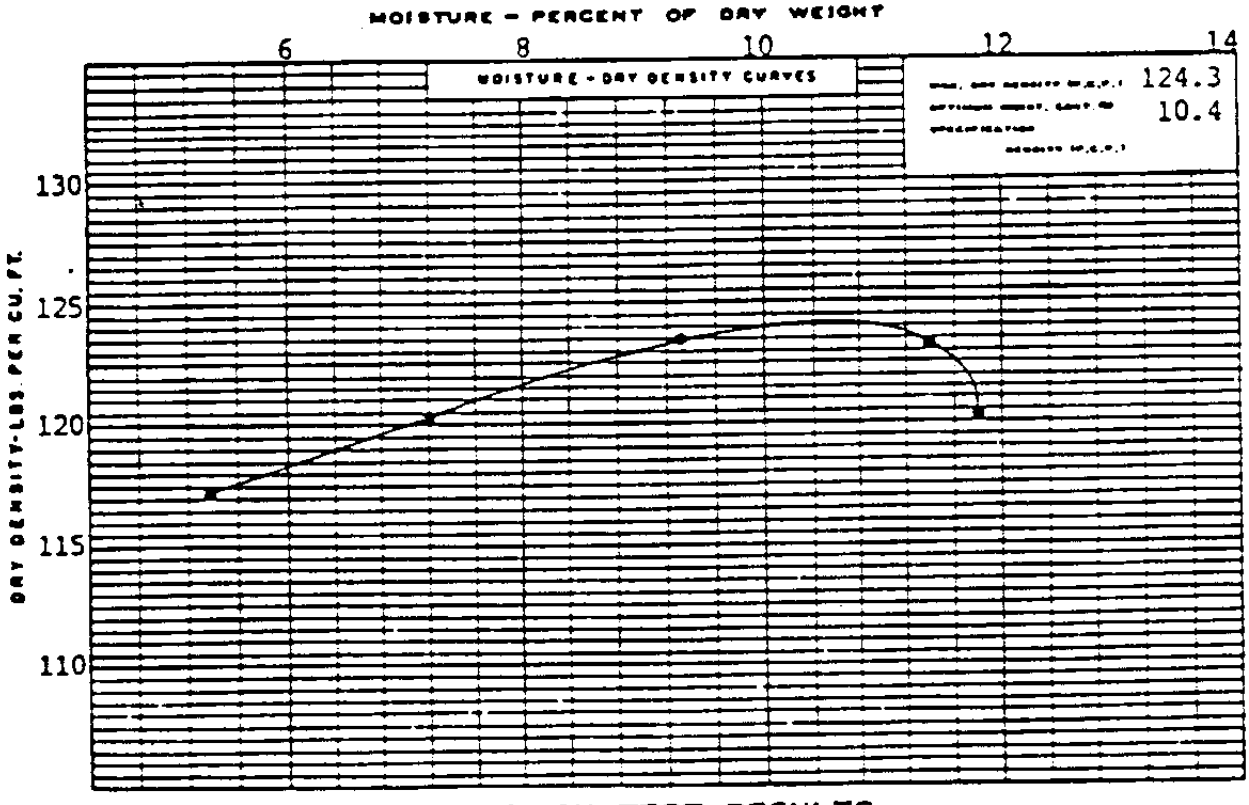
Soil and Foundation Engineering



GRADATION TEST RESULTS

GRAVEL 25 % SAND 37 % SILT AND CLAY 38 %

LIQUID LIMIT % PLASTICITY INDEX %



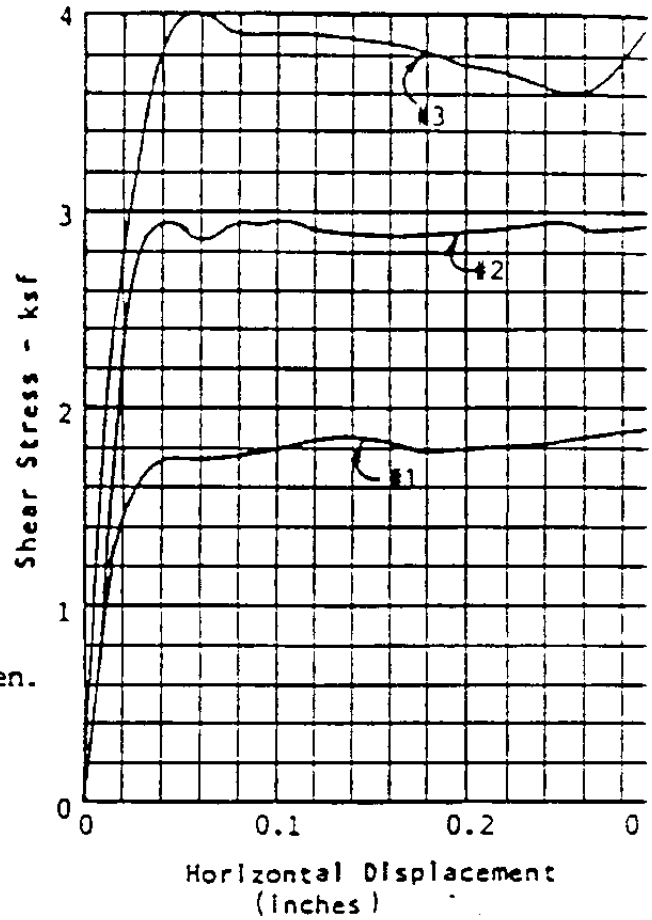
COMPACTION TEST RESULTS

COMPACTION TEST PROCEDURE ASTM D-698 Method C

SAMPLE OF Clayey Sand and Gravel

#525284 FROM DEPTH

TEST NUMBER	1	2	3	4
LOCATION				
HEIGHT-INCH	.75	.75	.75	
DIAMETER-INCH	1.925	1.925	1.925	
WATER CONTENT - %	10.0	10.0	10.0	
DRY DENSITY - pcf	117.8	117.8	117.8	
CONSOL. LOAD - ksf	2.0	4.0	6.0	
NORMAL LOAD - ksf	2.0	4.0	6.0	
SHEAR STRESS - ksf	1.8	3.0	4.0	



TYPE OF SPECIMEN: Remolded @ 95% Std.Proctor Den.

SOIL DESCRIPTION: Clayey Sand and Gravel

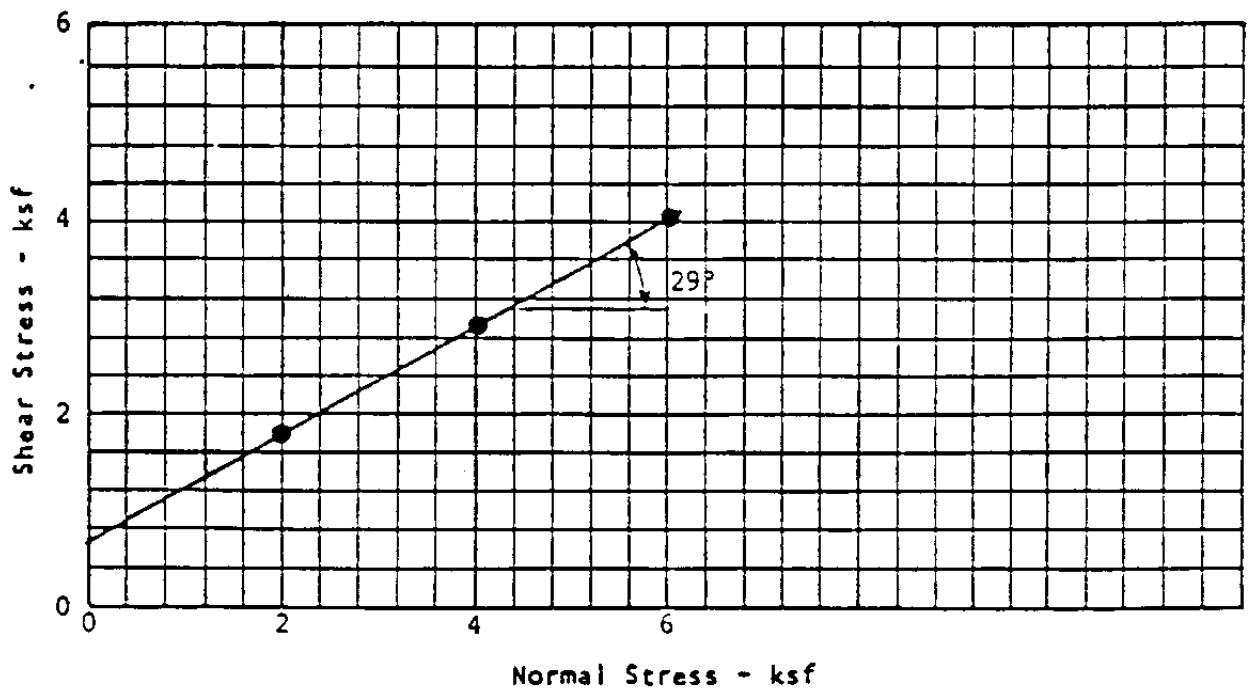
TYPE OF TEST: Consolidated-Undrained
Saturated

Strain Rate 0.02 in/sec

TAN Ø

Ø: 29°

COHESION - ksf: 0.7



#S25284

DIRECT SHEAR TEST RESULTS

HORROCKS ENGINEERS

7/12/83

SLOPE STABILITY ANALYSIS

for

CO-OP MINE - SLOPE STABILITY ** SEDIMENT POND A

DATA FILE: "CPSLOA:T14"

PROJECT NUMBER: 8309-42

by: EGN

Interior Slope

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	108.0	94.0	10.0	4.57

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	255.8	-41.3	700	1.7	120.3	29	101.4
2	670.6	-29.1	700	1.7	315.4	29	103.2
3	994.6	-18.3	700	1.7	467.8	29	104.9
4	1248.6	-8.2	700	1.7	587.2	29	106.6
5	1441.1	1.7	700	1.7	677.7	29	108.3
6	1573.8	11.6	700	1.7	740.1	29	110.0
7	1642.9	21.9	700	1.7	772.6	29	111.7
8	1636.9	33.1	700	1.7	769.8	29	113.4
9	1527.4	46.0	700	1.7	718.3	29	115.1
10	702.7	58.1	700	.9	352.0	29	116.5
11	555.8	71.0	700	.9	326.0	29	117.4
12	69.9	83.6	700	.2	50.6	29	117.9

ITERATION	INITIAL	CALCULATED
1	1.0000	4.3859
2	4.3859	4.5570
3	4.5570	4.5669
4	4.5669	4.5674

FACTOR OF SAFETY= 4.57 AT X= 108 Y= 94 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	110.0	98.0	10.0	5.71

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	119.8	-26.5	700	1.4	56.3	29	105.5
2	327.1	-17.9	700	1.4	153.8	29	106.9
3	497.2	-9.6	700	1.4	233.8	29	108.3
4	633.8	-1.6	700	1.4	298.1	29	109.7
5	738.4	6.5	700	1.4	347.2	29	111.1
6	810.3	14.6	700	1.4	381.1	29	112.5
7	846.8	23.1	700	1.4	398.2	29	113.9
8	842.0	32.1	700	1.4	396.0	29	115.3
9	571.3	40.6	700	1.0	294.8	29	116.5
10	514.1	48.8	700	1.0	320.2	29	117.5
11	423.2	59.6	700	1.1	331.7	29	118.6
12	94.5	72.3	700	.7	94.5	29	119.5

ITERATION	INITIAL	CALCULATED
1	1.0000	4.9462
2	4.9462	5.6651
3	5.6651	5.7085
4	5.7085	5.7108

FACTOR OF SAFETY= 5.71 AT X= 110 Y= 98 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	104.0	98.0	10.0	10.14

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	35.5	-7.0	700	1.0	16.7	29	102.8
2	98.5	-1.5	700	1.0	46.3	29	103.7
3	150.9	4.1	700	1.0	71.0	29	104.7
4	192.6	9.6	700	1.0	90.6	29	105.7
5	223.2	15.3	700	1.0	105.0	29	106.6
6	242.0	21.1	700	1.0	113.8	29	107.6
7	247.7	27.2	700	1.0	116.5	29	108.6
8	238.3	33.6	700	1.0	112.1	29	109.5
9	210.4	40.6	700	1.0	99.0	29	110.5
10	158.0	48.4	700	1.0	74.3	29	111.5
11	68.2	57.8	700	1.0	32.1	29	112.4

ITERATION	INITIAL	CALCULATED
1	1.0000	8.2214
2	8.2214	10.0653
3	10.0653	10.1340
4	10.1340	10.1361

FACTOR OF SAFETY= 10.14 AT X= 104 Y= 98 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	109.0	98.0	15.0	3.94

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	74.3	-39.9	700	1.2	34.9	29	99.4
2	632.5	-31.7	700	2.3	297.4	29	101.1
3	1249.7	-21.9	700	2.3	587.7	29	103.4
4	1748.2	-12.7	700	2.3	822.2	29	105.7
5	2145.1	-3.8	700	2.3	1008.8	29	108.0
6	2446.9	4.9	700	2.3	1150.8	29	110.3
7	2653.4	13.8	700	2.3	1247.8	29	112.6
8	2756.6	23.1	700	2.3	1296.4	29	114.9
9	2400.4	32.3	700	2.0	1233.4	29	117.0
10	2639.8	43.5	700	2.5	1569.2	29	119.3
11	1738.0	59.6	700	2.5	1277.1	29	121.8
12	209.5	75.7	700	.9	209.5	29	123.4

ITERATION	INITIAL	CALCULATED
1	1.0000	3.6937
2	3.6937	3.9291
3	3.9291	3.9432
4	3.9432	3.9440

FACTOR OF SAFETY= 3.94 AT X= 109 Y= 98 R= 15
EARTHQUAKE= .10

Interior Slope

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	106.0	94.0	15.0	4.09

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	549.4	-54.2	700	2.4	258.4	29	93.9
2	1283.4	-40.2	700	2.4	603.6	29	96.4
3	1755.6	-28.9	700	2.4	825.7	29	98.8
4	2488.6	-18.2	700	2.7	1170.4	29	101.3
5	3099.3	-7.7	700	2.7	1457.5	29	104.0
6	3555.5	2.6	700	2.7	1672.1	29	106.7
7	3861.2	12.9	700	2.7	1815.9	29	109.3
8	4004.5	23.7	700	2.7	1883.3	29	112.0
9	3950.6	35.5	700	2.7	1857.9	29	114.7
10	2756.1	47.5	700	2.0	1400.7	29	117.0
11	1680.6	58.4	700	1.4	961.8	29	118.7
12	1178.1	73.0	700	1.4	768.7	29	120.1
13	48.8	84.9	700	.1	42.6	29	120.9

ITERATION	INITIAL	CALCULATED
1	1.0000	5.0280
2	5.0280	4.1140
3	4.1140	4.0898
4	4.0898	4.0892

FACTOR OF SAFETY= 4.09 AT X= 106 Y= 94 R= 15
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	105.0	101.0	15.0	4.90

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	3.3	-20.3	700	.4	1.5	29	99.8
2	182.2	-15.9	700	1.8	85.7	29	100.9
3	450.4	-9.0	700	1.8	211.8	29	102.7
4	672.6	-2.1	700	1.8	316.3	29	104.4
5	850.5	4.7	700	1.8	400.0	29	106.2
6	983.6	11.6	700	1.8	462.6	29	108.0
7	1069.7	18.6	700	1.8	503.0	29	109.8
8	1103.5	26.0	700	1.8	519.0	29	111.6
9	1076.2	33.8	700	1.8	506.1	29	113.3
10	970.8	42.6	700	1.8	456.5	29	115.1
11	457.1	50.1	700	1.0	241.1	29	116.5
12	358.3	56.6	700	1.0	246.9	29	117.5
13	93.8	61.6	700	.4	84.3	29	118.2
14	89.2	66.8	700	.8	89.2	29	118.8

ITERATION	INITIAL	CALCULATED
1	1.0000	4.1830
2	4.1830	4.8519
3	4.8519	4.8964
4	4.8964	4.8990

FACTOR OF SAFETY= 4.90 AT X= 105 Y= 101 R= 15
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	106.0	102.0	15.0	5.22

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	153.5	-14.2	700	1.8	72.2	29	102.3
2	422.0	-7.1	700	1.8	198.5	29	104.2
3	641.7	-.1	700	1.8	301.8	29	106.0
4	813.8	6.9	700	1.8	382.7	29	107.8
5	937.2	14.0	700	1.8	440.8	29	109.6
6	1008.4	21.3	700	1.8	474.2	29	111.4
7	1020.4	29.1	700	1.8	479.9	29	113.3
8	960.7	37.4	700	1.8	451.8	29	115.1
9	466.7	44.5	700	1.0	245.6	29	116.5
10	398.2	50.1	700	1.0	265.7	29	117.5
11	215.7	55.6	700	.7	184.1	29	118.4
12	124.6	62.3	700	1.0	124.6	29	119.2

ITERATION	INITIAL	CALCULATED
1	1.0000	4.4326
2	4.4326	5.1679
3	5.1679	5.2127
4	5.2127	5.2151

FACTOR OF SAFETY= 5.22 AT X= 106 Y= 102 R= 15
EARTHQUAKE= .10

Interior Slope

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	109.0	100.0	20.0	3.78

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	591.0	-43.3	700	3.1	277.9	29	95.4
2	1457.2	-32.0	700	3.1	685.3	29	98.5
3	2405.2	-21.8	700	3.2	1131.2	29	101.6
4	3375.3	-12.2	700	3.2	1587.4	29	104.8
5	4137.1	-2.9	700	3.2	1945.6	29	108.0
6	4703.9	6.3	700	3.2	2212.2	29	111.2
7	5072.8	15.7	700	3.2	2385.7	29	114.4
8	3258.4	23.6	700	2.0	1636.9	29	117.0
9	4602.0	31.8	700	3.0	2572.6	29	119.5
10	3801.3	42.7	700	3.0	2385.6	29	122.5
11	2580.8	56.4	700	3.0	2001.1	29	125.5
12	1.2	64.2	700	.0	1.2	29	127.0
13	453.1	70.3	700	1.4	453.1	29	127.7

ITERATION	INITIAL	CALCULATED
1	1.0000	3.7806
2	3.7806	3.7785

FACTOR OF SAFETY= 3.78 AT X= 109 Y= 100 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	106.0	106.0	20.0	4.41

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	1.1	-17.8	700	.2	.5	29	99.9
2	261.9	-14.1	700	2.3	123.2	29	101.1
3	686.1	-7.4	700	2.3	322.7	29	103.4
4	1038.0	-.8	700	2.3	488.2	29	105.7
5	1319.3	5.7	700	2.3	620.4	29	108.0
6	1528.9	12.4	700	2.3	719.0	29	110.3
7	1662.7	19.2	700	2.3	782.0	29	112.6
8	1712.6	26.3	700	2.3	805.4	29	114.9
9	1461.5	33.4	700	2.0	791.8	29	117.0
10	1055.6	40.0	700	1.7	701.8	29	118.8
11	742.9	46.7	700	1.7	614.1	29	120.5
12	353.9	55.1	700	2.0	353.9	29	122.3

ITERATION	INITIAL	CALCULATED
1	1.0000	3.8643
2	3.8643	4.3791
3	4.3791	4.4085
4	4.4085	4.4100

FACTOR OF SAFETY= 4.41 AT X= 106 Y= 106 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	102.0	104.0	20.0	4.95

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	269.2	-27.2	700	2.8	126.6	29	92.9
2	667.8	-18.3	700	2.8	314.1	29	95.7
3	906.6	-9.9	700	2.8	426.4	29	98.6
4	1148.3	-1.9	700	2.7	540.0	29	101.3
5	1539.2	5.8	700	2.7	723.9	29	104.0
6	1816.1	13.5	700	2.7	854.1	29	106.7
7	1970.8	21.6	700	2.7	926.8	29	109.3
8	1985.5	30.1	700	2.7	933.7	29	112.0
9	1825.4	39.5	700	2.7	858.5	29	114.7
10	1114.1	48.8	700	2.0	628.5	29	117.0
11	462.2	56.4	700	1.3	366.0	29	118.6
12	141.8	63.0	700	1.1	141.8	29	119.8

ITERATION	INITIAL	CALCULATED
1	1.0000	4.5173
2	4.5173	4.9325
3	4.9325	4.9501
4	4.9501	4.9508

FACTOR OF SAFETY= 4.95 AT X= 102 Y= 104 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	102.0	107.0	20.0	6.40

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	103.9	-2.7	700	1.8	48.8	29	101.0
2	287.4	2.3	700	1.8	135.2	29	102.8
3	438.8	7.4	700	1.8	206.4	29	104.6
4	557.3	12.5	700	1.8	262.1	29	106.3
5	641.2	17.7	700	1.8	301.5	29	108.1
6	687.9	23.1	700	1.8	323.5	29	109.8
7	693.2	28.7	700	1.8	326.0	29	111.6
8	650.7	34.7	700	1.8	306.0	29	113.4
9	550.2	41.1	700	1.8	258.7	29	115.1
10	346.6	47.8	700	1.6	228.6	29	116.8
11	57.2	52.2	700	.4	57.2	29	117.8
12	42.8	54.9	700	.7	42.8	29	118.4

ITERATION	INITIAL	CALCULATED
1	1.0000	5.2973
2	5.2973	6.3473
3	6.3473	6.4019
4	6.4019	6.4043

FACTOR OF SAFETY= 6.40 AT X= 102 Y= 107 R= 20
EARTHQUAKE= .10

Exterior Slope

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	53.0	86.0	10.0	4.67

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	.0	-63.4	700	.0	.0	29	44.1
2	403.4	-54.5	700	1.8	207.0	29	45.0
3	984.1	-39.0	700	1.8	512.6	29	46.7
4	1413.9	-26.7	700	1.8	747.1	29	48.5
5	1747.3	-15.6	700	1.8	936.3	29	50.3
6	2004.4	-5.1	700	1.8	1089.7	29	52.1
7	2192.7	5.2	700	1.8	1210.7	29	53.9
8	2312.3	15.6	700	1.8	1299.3	29	55.7
9	2355.5	26.7	700	1.8	1352.1	29	57.5
10	2302.3	39.1	700	1.8	1359.5	29	59.3
11	2097.9	54.6	700	1.8	1295.8	29	61.1
12	846.5	71.4	700	.9	562.6	29	62.4

ITERATION	INITIAL	CALCULATED
1	1.0000	5.9845
2	5.9845	4.6933
3	4.6933	4.6741
4	4.6741	4.6738

FACTOR OF SAFETY= 4.67 AT X= 53 Y= 86 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	50.0	92.0	10.0	7.29

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	15.8	-19.6	700	.6	15.8	29	46.6
2	143.2	-14.2	700	1.3	112.5	29	47.5
3	270.5	-6.9	700	1.3	188.3	29	48.8
4	373.8	.3	700	1.3	252.9	29	50.1
5	453.8	7.6	700	1.3	306.5	29	51.3
6	509.8	14.9	700	1.3	348.8	29	52.6
7	539.8	22.5	700	1.3	378.9	29	53.8
8	540.1	30.6	700	1.3	395.0	29	55.1
9	503.4	39.4	700	1.3	393.7	29	56.3
10	415.0	49.7	700	1.3	368.1	29	57.6
11	162.0	59.2	700	.7	162.0	29	58.6
12	72.6	68.8	700	.7	72.6	29	59.3

ITERATION	INITIAL	CALCULATED
1	1.0000	6.0224
2	6.0224	7.2216
3	7.2216	7.2876
4	7.2876	7.2907

FACTOR OF SAFETY= 7.29 AT X= 50 Y= 92 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	52.0	94.0	10.0	9.24

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	36.9	-11.2	700	.9	36.9	29	50.1
2	103.3	-5.8	700	.9	103.3	29	51.0
3	174.9	-.3	700	1.0	163.3	29	52.0
4	228.9	5.5	700	1.0	198.9	29	53.0
5	270.8	11.3	700	1.0	228.9	29	54.0
6	299.9	17.3	700	1.0	252.8	29	55.0
7	315.3	23.5	700	1.0	270.3	29	56.0
8	315.1	29.9	700	1.0	280.5	29	57.0
9	296.4	36.8	700	1.0	281.9	29	58.0
10	232.0	44.1	700	.9	232.0	29	58.9
11	173.4	51.9	700	.9	173.4	29	59.8
12	75.7	61.6	700	.9	75.7	29	60.8

ITERATION	INITIAL	CALCULATED
1	1.0000	7.5257
2	7.5257	9.1670
3	9.1670	9.2357
4	9.2357	9.2381

FACTOR OF SAFETY= 9.24 AT X= 52 Y= 94 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	46.0	92.0	10.0	13.12

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	6.4	-4.0	700	.4	6.4	29	45.3
2	48.3	-.3	700	.9	39.8	29	45.9
3	89.1	4.7	700	.9	66.6	29	46.8
4	122.1	9.7	700	.9	89.7	29	47.7
5	147.1	14.8	700	.9	109.0	29	48.5
6	163.6	20.0	700	.9	124.4	29	49.4
7	171.0	25.3	700	.9	135.5	29	50.3
8	168.0	31.0	700	.9	141.6	29	51.1
9	152.7	37.8	700	.9	142.1	29	52.0
10	101.1	42.8	700	.7	101.1	29	52.8
11	71.7	48.5	700	.7	71.7	29	53.5
12	28.7	54.9	700	.7	28.7	29	54.2

ITERATION	INITIAL	CALCULATED
1	1.0000	10.5338
2	10.5338	13.0454
3	13.0454	13.1176
4	13.1176	13.1192

FACTOR OF SAFETY= 13.12 AT X= 46 Y= 92 R= 10
EARTHQUAKE= .10

Exterior Slope

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	57.0	90.0	15.0	3.50

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	.2	-56.4	700	.0	.2	29	44.5
2	771.2	-48.6	700	2.7	412.6	29	45.9
3	1918.5	-34.7	700	2.7	1023.9	29	48.5
4	2790.9	-23.0	700	2.7	1505.9	29	51.2
5	3470.9	-12.2	700	2.7	1897.5	29	53.8
6	3991.0	-2.0	700	2.7	2213.8	29	56.5
7	4361.8	8.3	700	2.7	2460.0	29	59.2
8	4578.8	18.8	700	2.7	2633.8	29	61.8
9	4619.4	30.0	700	2.7	2724.6	29	64.5
10	4426.6	42.9	700	2.7	2705.7	29	67.1
11	3832.4	60.1	700	2.7	2498.0	29	69.8
12	894.7	78.3	700	.8	658.1	29	71.5

ITERATION	INITIAL	CALCULATED
1	1.0000	3.6880
2	3.6880	3.5051
3	3.5051	3.4972
4	3.4972	3.4969

FACTOR OF SAFETY= 3.50 AT X= 57 Y= 90 R= 15
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	58.0	98.0	15.0	4.45

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	105.4	-26.1	700	1.3	105.4	29	51.4
2	558.7	-19.0	700	2.1	458.1	29	53.1
3	959.9	-10.7	700	2.1	691.9	29	55.2
4	1282.8	-2.5	700	2.1	889.0	29	57.3
5	1531.3	5.6	700	2.1	1051.0	29	59.5
6	1704.3	13.8	700	2.1	1177.6	29	61.6
7	1796.2	22.3	700	2.1	1266.0	29	63.7
8	1793.9	31.4	700	2.1	1310.1	29	65.8
9	1670.8	41.5	700	2.1	1297.4	29	67.9
10	1365.3	53.8	700	2.1	1198.9	29	70.0
11	624.6	71.3	700	1.8	624.6	29	72.0

ITERATION	INITIAL	CALCULATED
1	1.0000	3.8124
2	3.8124	4.4023
3	4.4023	4.4514
4	4.4514	4.4550

FACTOR OF SAFETY= 4.45 AT X= 58 Y= 98 R= 15
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	52.0	96.0	15.0	4.70

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	7.3	-23.9	700	.4	7.3	29	45.9
2	264.1	-19.3	700	1.9	182.7	29	47.0
3	593.0	-11.8	700	1.9	373.9	29	48.9
4	864.7	-4.5	700	1.9	538.1	29	50.8
5	1082.3	2.8	700	1.9	676.8	29	52.7
6	1246.8	10.1	700	1.9	790.2	29	54.6
7	1353.5	17.6	700	1.9	877.2	29	56.5
8	1398.9	25.4	700	1.9	934.9	29	58.4
9	1371.1	33.8	700	1.9	958.3	29	60.3
10	1248.9	43.1	700	1.9	937.2	29	62.2
11	985.1	54.3	700	1.9	849.5	29	64.1
12	412.6	69.1	700	1.6	412.6	29	65.9

ITERATION	INITIAL	CALCULATED
1	1.0000	3.9771
2	3.9771	4.6404
3	4.6404	4.6925
4	4.6925	4.6961

FACTOR OF SAFETY= 4.70 AT X= 52 Y= 96 R= 15
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	220.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	47.0	97.0	15.0	8.30

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	7.2	-6.8	700	.4	7.2	29	45.4
2	113.9	-2.4	700	1.4	88.1	29	46.4
3	233.3	3.1	700	1.4	165.0	29	47.8
4	329.4	8.6	700	1.4	231.0	29	49.2
5	401.6	14.2	700	1.4	285.8	29	50.7
6	448.4	19.9	700	1.4	328.6	29	52.1
7	467.3	25.9	700	1.4	358.3	29	53.5
8	454.3	32.2	700	1.4	373.0	29	55.0
9	403.0	38.9	700	1.4	369.7	29	56.4
10	302.2	46.4	700	1.4	302.2	29	57.8
11	128.9	55.2	700	1.4	128.9	29	59.3

ITERATION	INITIAL	CALCULATED
1	1.0000	6.7507
2	6.7507	8.2322
3	8.2322	8.2974
4	8.2974	8.2998

FACTOR OF SAFETY= 8.30 AT X= 47 Y= 97 R= 15
EARTHQUAKE= .10

Exterior Slope

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	58.0	95.0	20.0	3.00

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	35.8	-46.0	700	.8	16.8	29	43.6
2	1141.1	-38.5	700	3.2	589.3	29	45.6
3	2540.2	-27.4	700	3.2	1352.6	29	48.8
4	3653.0	-17.4	700	3.2	1981.2	29	52.1
5	4537.0	-7.8	700	3.2	2502.2	29	55.3
6	5216.8	1.4	700	3.2	2927.2	29	58.5
7	5698.1	10.8	700	3.2	3258.8	29	61.7
8	5970.8	20.4	700	3.2	3491.9	29	64.9
9	5999.8	30.7	700	3.2	3611.2	29	68.2
10	5713.3	42.3	700	3.2	3581.8	29	71.4
11	3659.4	54.7	700	2.4	2377.4	29	74.2
12	2355.2	72.4	700	2.4	1638.0	29	76.7
13	25.1	85.6	700	.1	25.1	29	77.9

ITERATION	INITIAL	CALCULATED
1	1.0000	2.8932
2	2.8932	2.9918
3	2.9918	2.9982
4	2.9982	2.9986

FACTOR OF SAFETY= 3.00 AT X= 58 Y= 95 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	50.0	100.0	20.0	4.21

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	58.1	-19.9	700	1.6	27.3	29	43.2
2	468.3	-13.7	700	2.5	252.9	29	45.3
3	981.2	-6.3	700	2.5	559.4	29	47.8
4	1395.7	1.0	700	2.5	819.6	29	50.3
5	1713.5	8.3	700	2.5	1034.4	29	52.9
6	1931.5	15.8	700	2.5	1202.2	29	55.4
7	2048.9	23.5	700	2.5	1319.0	29	58.0
8	2024.6	31.7	700	2.5	1376.5	29	60.5
9	1849.6	40.8	700	2.5	1359.5	29	63.0
10	1446.3	51.5	700	2.5	1235.2	29	65.6
11	603.2	65.0	700	2.3	603.2	29	68.0

ITERATION	INITIAL	CALCULATED
1	1.0000	3.6025
2	3.6025	4.1625
3	4.1625	4.2063
4	4.2063	4.2093

FACTOR OF SAFETY= 4.21 AT X= 50 Y= 100 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	52.0	102.0	20.0	4.61

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	21.2	-14.9	700	.7	21.2	29	46.9
2	355.1	-10.6	700	2.3	266.6	29	48.3
3	733.9	-4.0	700	2.3	496.7	29	50.6
4	1043.7	2.5	700	2.3	694.3	29	52.9
5	1284.8	9.0	700	2.3	859.6	29	55.1
6	1454.7	15.7	700	2.3	991.5	29	57.4
7	1547.7	22.6	700	2.3	1087.2	29	59.7
8	1553.5	29.8	700	2.3	1141.9	29	61.9
9	1453.8	37.6	700	2.3	1146.9	29	64.2
10	1214.3	46.5	700	2.3	1086.2	29	66.4
11	581.7	55.0	700	1.5	581.7	29	68.4
12	250.1	64.0	700	1.5	250.1	29	69.9

ITERATION	INITIAL	CALCULATED
1	1.0000	3.8773
2	3.8773	4.5600
3	4.5600	4.6115
4	4.6115	4.6148

FACTOR OF SAFETY= 4.61 AT X= 52 Y= 102 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	46.0	102.0	20.0	7.88

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	6.6	-2.1	700	.5	6.6	29	45.3
2	125.4	.9	700	1.6	97.1	29	46.3
3	263.6	5.6	700	1.6	189.0	29	47.9
4	376.1	10.3	700	1.6	268.7	29	49.6
5	461.9	15.1	700	1.6	335.9	29	51.2
6	519.5	20.0	700	1.6	389.8	29	52.8
7	546.5	25.0	700	1.6	429.3	29	54.4
8	539.3	30.3	700	1.6	452.8	29	56.1
9	492.6	35.9	700	1.6	457.6	29	57.7
10	338.0	41.3	700	1.3	338.0	29	59.2
11	239.0	46.7	700	1.3	239.0	29	60.5
12	94.8	52.7	700	1.3	94.8	29	61.9

ITERATION	INITIAL	CALCULATED
1	1.0000	6.4094
2	6.4094	7.8126
3	7.8126	7.8758
4	7.8758	7.8782

FACTOR OF SAFETY= 7.88 AT X= 46 Y= 102 R= 20
EARTHQUAKE= .10

Exterior Slope

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	57.0	99.0	25.0	2.82

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	330.9	-41.8	700	2.4	155.6	29	40.4
2	876.6	-34.7	700	2.4	412.3	29	42.8
3	2938.2	-26.0	700	4.1	1468.8	29	46.1
4	4718.6	-15.8	700	4.1	2480.1	29	50.2
5	6119.1	-6.1	700	4.1	3312.9	29	54.4
6	7176.4	3.5	700	4.1	3984.1	29	58.5
7	7894.5	13.1	700	4.1	4495.8	29	62.6
8	8246.7	23.1	700	4.1	4835.5	29	66.8
9	8162.1	34.1	700	4.1	4969.8	29	70.9
10	7138.5	47.0	700	4.3	4419.6	29	75.1
11	4073.3	66.5	700	4.3	2595.1	29	79.4
12	35.2	81.0	700	.3	35.2	29	81.7

ITERATION	INITIAL	CALCULATED
1	1.0000	2.7148
2	2.7148	2.8136
3	2.8136	2.8196
4	2.8196	2.8200

FACTOR OF SAFETY= 2.82 AT X= 57 Y= 99 R= 25
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	50.0	100.0	25.0	3.27

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	633.0	-37.1	700	3.6	297.7	29	35.0
2	1590.7	-27.2	700	3.6	748.1	29	38.6
3	2230.1	-18.2	700	3.6	1048.8	29	42.2
4	3526.1	-9.1	700	4.1	1745.3	29	46.1
5	4688.1	.5	700	4.1	2465.8	29	50.2
6	5512.7	10.1	700	4.1	3027.7	29	54.4
7	5983.5	20.0	700	4.1	3423.1	29	58.5
8	6046.2	30.5	700	4.1	3626.6	29	62.6
9	5573.1	42.5	700	4.1	3578.2	29	66.8
10	4216.0	57.9	700	4.1	3114.0	29	70.9
11	382.4	68.5	700	.5	284.9	29	73.2
12	376.3	75.4	700	1.2	376.3	29	74.1

ITERATION	INITIAL	CALCULATED
1	1.0000	3.0608
2	3.0608	3.2527
3	3.2527	3.2655
4	3.2655	3.2663

FACTOR OF SAFETY= 3.27 AT X= 50 Y= 100 R= 25
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	48.0	106.0	25.0	4.72

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	10.8	-10.3	700	1.0	5.1	29	43.5
2	283.9	-6.3	700	2.5	164.9	29	45.2
3	692.3	-.6	700	2.5	419.6	29	47.7
4	1028.1	5.1	700	2.5	640.2	29	50.2
5	1290.4	10.9	700	2.5	826.3	29	52.7
6	1475.9	16.7	700	2.5	976.3	29	55.2
7	1578.7	22.8	700	2.5	1087.3	29	57.7
8	1588.6	29.2	700	2.5	1154.6	29	60.2
9	1488.9	36.0	700	2.5	1170.4	29	62.6
10	1251.1	43.4	700	2.5	1121.3	29	65.1
11	687.7	50.9	700	1.9	687.7	29	67.4
12	284.9	58.7	700	1.9	284.9	29	69.3

ITERATION	INITIAL	CALCULATED
1	1.0000	3.9636
2	3.9636	4.6680
3	4.6680	4.7174
4	4.7174	4.7203

FACTOR OF SAFETY= 4.72 AT X= 48 Y= 106 R= 25
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	42.0	106.0	25.0	11.03

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	56.9	-8.8	700	2.3	26.7	29	38.2
2	124.8	-3.4	700	2.3	58.7	29	40.5
3	133.1	1.9	700	2.3	62.6	29	42.8
4	210.3	7.0	700	2.1	121.7	29	45.1
5	386.5	12.0	700	2.1	250.1	29	47.2
6	514.6	17.0	700	2.1	355.9	29	49.3
7	591.2	22.2	700	2.1	437.5	29	51.4
8	611.2	27.5	700	2.1	492.5	29	53.5
9	566.4	33.2	700	2.1	517.0	29	55.7
10	477.6	39.5	700	2.3	477.6	29	57.9
11	202.3	46.9	700	2.3	202.3	29	60.2

ITERATION	INITIAL	CALCULATED
1	1.0000	9.4221
2	9.4221	10.9930
3	10.9930	11.0292
4	11.0292	11.0299

FACTOR OF SAFETY= 11.03 AT X= 42 Y= 106 R= 25
EARTHQUAKE= .10

Exterior Slope

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	55.0	102.0	30.0	2.77

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	763.6	-42.2	700	3.6	359.1	29	34.9
2	1963.7	-33.4	700	3.6	923.5	29	38.5
3	2836.0	-25.4	700	3.6	1333.7	29	42.2
4	5382.9	-16.7	700	4.8	2650.0	29	46.4
5	7339.0	-7.2	700	4.8	3806.8	29	51.3
6	8837.8	2.1	700	4.8	4748.5	29	56.1
7	9889.4	11.4	700	4.8	5480.0	29	60.9
8	10466.6	21.1	700	4.8	5988.3	29	65.8
9	10491.6	31.5	700	4.8	6236.9	29	70.6
10	8552.9	42.7	700	4.5	5132.4	29	75.3
11	5806.7	56.4	700	4.5	3414.4	29	79.8
12	1006.1	69.7	700	2.0	577.7	29	83.8
13	6.3	75.8	700	.2	3.8	29	84.1

ITERATION	INITIAL	CALCULATED
1	1.0000	2.7349
2	2.7349	2.7707
3	2.7707	2.7723

FACTOR OF SAFETY= 2.77 AT X= 55 Y= 102 R= 30
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	50.0	100.0	30.0	3.00

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	1382.1	-45.9	700	4.4	612.4	29	28.6
2	3222.5	-34.7	700	4.4	1515.5	29	33.0
3	4525.5	-24.9	700	4.4	2128.3	29	37.4
4	5373.3	-15.9	700	4.4	2527.0	29	41.8
5	7113.4	-6.9	700	4.8	3463.8	29	46.4
6	8596.8	2.4	700	4.8	4398.3	29	51.3
7	9632.8	11.7	700	4.8	5122.4	29	56.1
8	10192.6	21.4	700	4.8	5622.5	29	60.9
9	10196.3	31.8	700	4.8	5861.2	29	65.8
10	9460.9	43.7	700	4.8	5752.2	29	70.6
11	4878.3	55.3	700	3.1	3112.1	29	74.6
12	2775.9	68.9	700	3.1	1916.7	29	77.7
13	80.3	79.8	700	.5	80.3	29	79.5

ITERATION	INITIAL	CALCULATED
1	1.0000	3.0347
2	3.0347	2.9976
3	2.9976	2.9960

FACTOR OF SAFETY= 3.00 AT X= 50 Y= 100 R= 30
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	45.8	105.0	30.0	3.77

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	827.9	-33.4	700	4.4	389.4	29	28.6
2	2069.8	-23.7	700	4.4	973.4	29	33.0
3	2867.2	-14.8	700	4.4	1348.4	29	37.4
4	3289.0	-6.2	700	4.4	1546.8	29	41.8
5	4095.7	2.5	700	4.6	2031.9	29	46.3
6	5028.9	11.3	700	4.6	2682.2	29	50.8
7	5562.9	20.4	700	4.6	3144.8	29	55.4
8	5638.5	30.1	700	4.6	3391.7	29	60.0
9	5126.7	40.9	700	4.6	3362.5	29	64.5
10	3713.4	54.2	700	4.6	2909.2	29	69.1
11	614.8	65.3	700	1.6	614.8	29	72.2
12	67.7	70.8	700	.6	67.7	29	73.3

ITERATION	INITIAL	CALCULATED
1	1.0000	3.5111
2	3.5111	3.7524
3	3.7524	3.7651
4	3.7651	3.7657

FACTOR OF SAFETY= 3.77 AT X= 45 Y= 105 R= 30
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	52.0	112.0	30.0	3.84

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	18.1	-10.6	700	.7	18.1	29	46.5
2	481.0	-7.1	700	2.9	352.3	29	48.3
3	1055.4	-1.6	700	2.9	708.2	29	51.2
4	1532.7	4.0	700	2.9	1018.5	29	54.1
5	1912.4	9.6	700	2.9	1282.8	29	57.0
6	2190.9	15.3	700	2.9	1499.7	29	59.9
7	2361.4	21.2	700	2.9	1665.6	29	62.8
8	2412.2	27.3	700	2.9	1775.3	29	65.7
9	2324.4	33.7	700	2.9	1819.9	29	68.6
10	2067.1	40.8	700	2.9	1784.7	29	71.5
11	594.6	45.8	700	1.0	570.9	29	73.5
12	674.7	49.7	700	1.7	674.7	29	74.9
13	247.9	55.8	700	1.7	247.9	29	76.5

ITERATION	INITIAL	CALCULATED
1	1.8000	3.3179
2	3.3179	3.8044
3	3.8044	3.8394
4	3.8394	3.8416

FACTOR OF SAFETY= 3.84 AT X= 52 Y= 112 R= 30
EARTHQUAKE= .10

Exterior Slope

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	55.0	105.0	35.0	2.77

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	1457.3	-42.3	700	5.0	685.4	29	31.6
2	3654.5	-32.0	700	5.0	1718.7	29	36.5
3	5159.2	-22.7	700	5.0	2426.3	29	41.5
4	8198.8	-13.4	700	5.8	4026.3	29	46.9
5	10777.7	-3.8	700	5.8	5580.3	29	52.7
6	12690.9	5.8	700	5.8	6821.2	29	58.5
7	13932.5	15.5	700	5.8	7746.2	29	64.3
8	14433.5	25.7	700	5.8	8322.9	29	70.1
9	10361.9	35.5	700	4.5	5983.1	29	75.3
10	8347.7	45.2	700	4.5	4609.4	29	79.8
11	2709.4	53.2	700	2.0	1378.7	29	83.0
12	2466.0	63.0	700	3.9	1159.7	29	85.9

ITERATION	INITIAL	CALCULATED
1	1.0000	2.7941
2	2.7941	2.7726
3	2.7726	2.7720

FACTOR OF SAFETY= 2.77 AT X= 55 Y= 105 R= 35
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	58.0	108.0	35.0	2.79

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	919.2	-36.3	700	4.4	432.3	29	37.4
2	2358.1	-27.7	700	4.4	1109.0	29	41.8
3	4404.6	-19.4	700	4.8	2189.9	29	46.4
4	6529.5	-11.1	700	4.8	3426.1	29	51.3
5	8249.6	-3.1	700	4.8	4471.9	29	56.1
6	9586.2	4.8	700	4.8	5337.4	29	60.9
7	10536.8	12.8	700	4.8	6021.3	29	65.8
8	11075.8	21.1	700	4.8	6511.3	29	70.6
9	9782.4	29.6	700	4.5	5710.6	29	75.3
10	8174.9	38.6	700	4.5	4528.1	29	79.8
11	2826.8	45.6	700	2.8	1433.6	29	83.8
12	3608.6	55.7	700	5.3	1697.1	29	86.7

ITERATION	INITIAL	CALCULATED
1	1.0000	2.7363
2	2.7363	2.7910
3	2.7910	2.7928

FACTOR OF SAFETY= 2.79 AT X= 58 Y= 108 R= 35
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	50.0	100.0	35.0	2.93

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	2844.9	-50.4	700	5.9	1337.9	29	23.3
2	6727.7	-36.7	700	5.9	3164.8	29	29.2
3	9199.3	-25.3	700	5.9	4326.3	29	35.1
4	10706.7	-14.9	700	5.9	5035.2	29	41.0
5	12170.2	-5.1	700	5.8	5894.0	29	46.9
6	14174.3	4.4	700	5.8	7177.7	29	52.7
7	15511.0	14.1	700	5.8	8147.4	29	58.5
8	16121.3	24.2	700	5.8	8775.6	29	64.3
9	15853.2	35.3	700	5.8	8990.6	29	70.1
10	10727.7	46.4	700	4.5	6155.1	29	75.3
11	7653.3	58.9	700	4.5	4282.8	29	79.8
12	1687.3	71.2	700	2.8	898.1	29	83.0
13	128.2	78.8	700	.6	60.3	29	84.3

ITERATION	INITIAL	CALCULATED
1	1.0000	3.2239
2	3.2239	2.9346
3	2.9346	2.9289
4	2.9289	2.9287

FACTOR OF SAFETY= 2.93 AT X= 50 Y= 100 R= 35
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	45.0	105.0	35.0	3.20

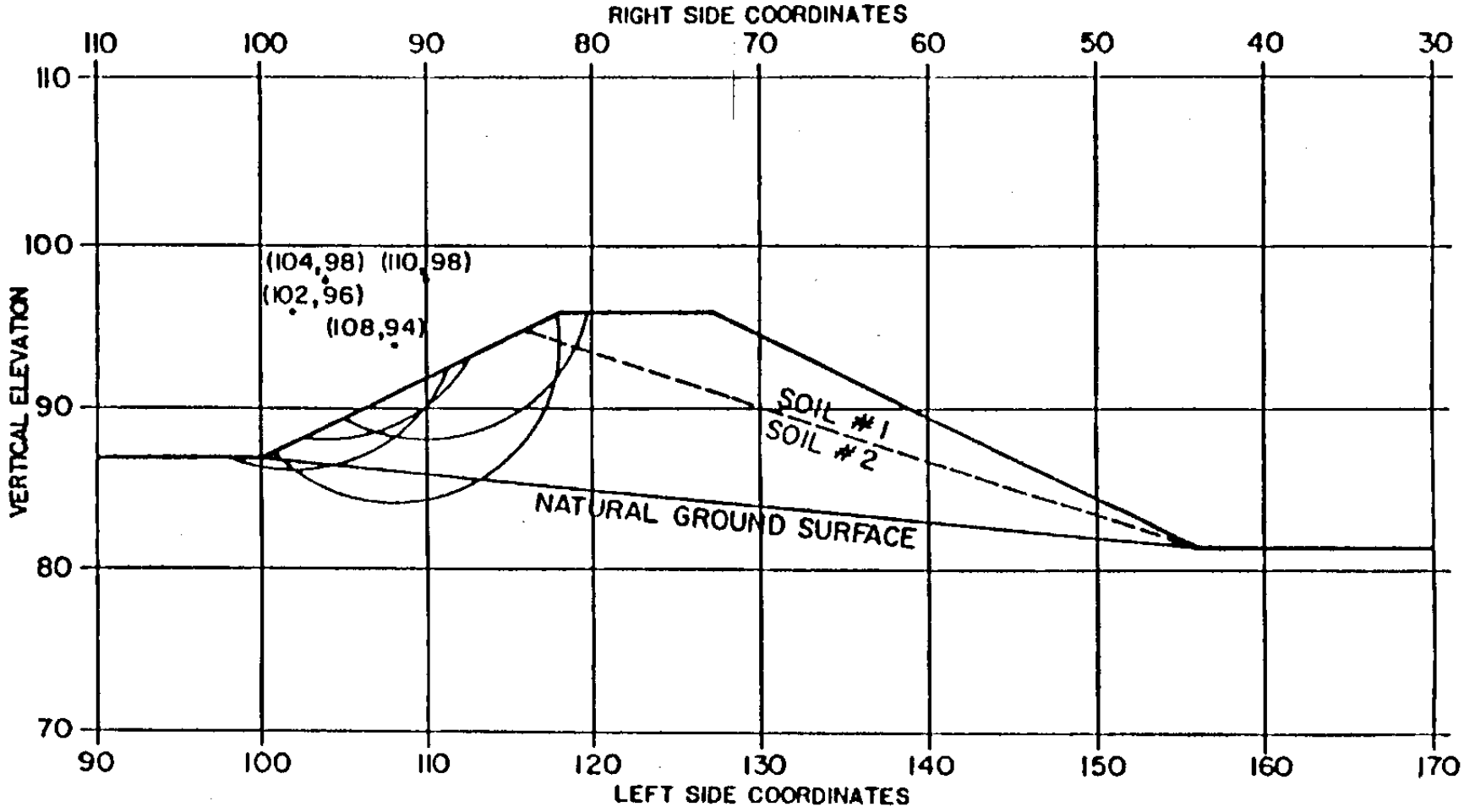
SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	1462.0	-42.3	700	5.0	687.5	29	21.6
2	3665.2	-32.0	700	5.0	1723.7	29	26.5
3	5173.8	-22.7	700	5.0	2432.8	29	31.5
4	6143.7	-14.1	700	5.0	2889.3	29	36.5
5	6653.8	-5.7	700	5.0	3129.2	29	41.5
6	8812.7	3.1	700	5.8	4315.1	29	46.9
7	10243.5	12.8	700	5.8	5329.1	29	52.7
8	10960.3	22.8	700	5.8	6007.3	29	58.5
9	10827.8	33.7	700	5.8	6286.1	29	64.3
10	9526.8	46.2	700	5.8	6015.0	29	70.1
11	4743.8	61.5	700	4.9	3409.3	29	75.4
12	198.1	72.5	700	1.0	198.1	29	78.3

ITERATION	INITIAL	CALCULATED
1	1.0000	3.1718
2	3.1718	3.1953
3	3.1953	3.1962

FACTOR OF SAFETY= 3.20 AT X= 45 Y= 105 R= 35
EARTHQUAKE= .10

BEAR CREEK CANYON MINE – SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



CO-OP MINING COMPANY

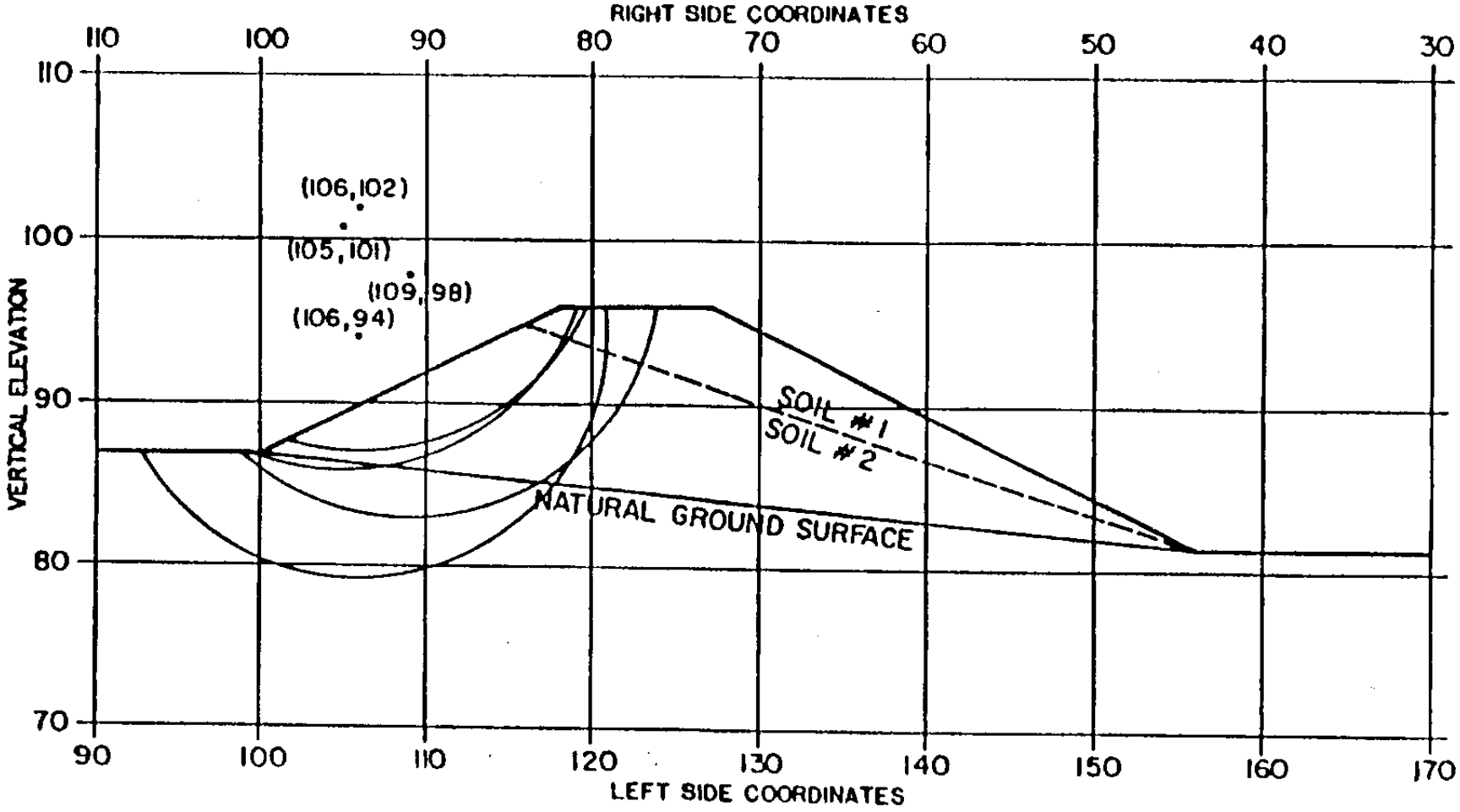
RADIUS = 10'

SCALE 1" = 10'

HORROCKS CAROLLO ENGINEERS

BEAR CREEK CANYON MINE - SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 15'

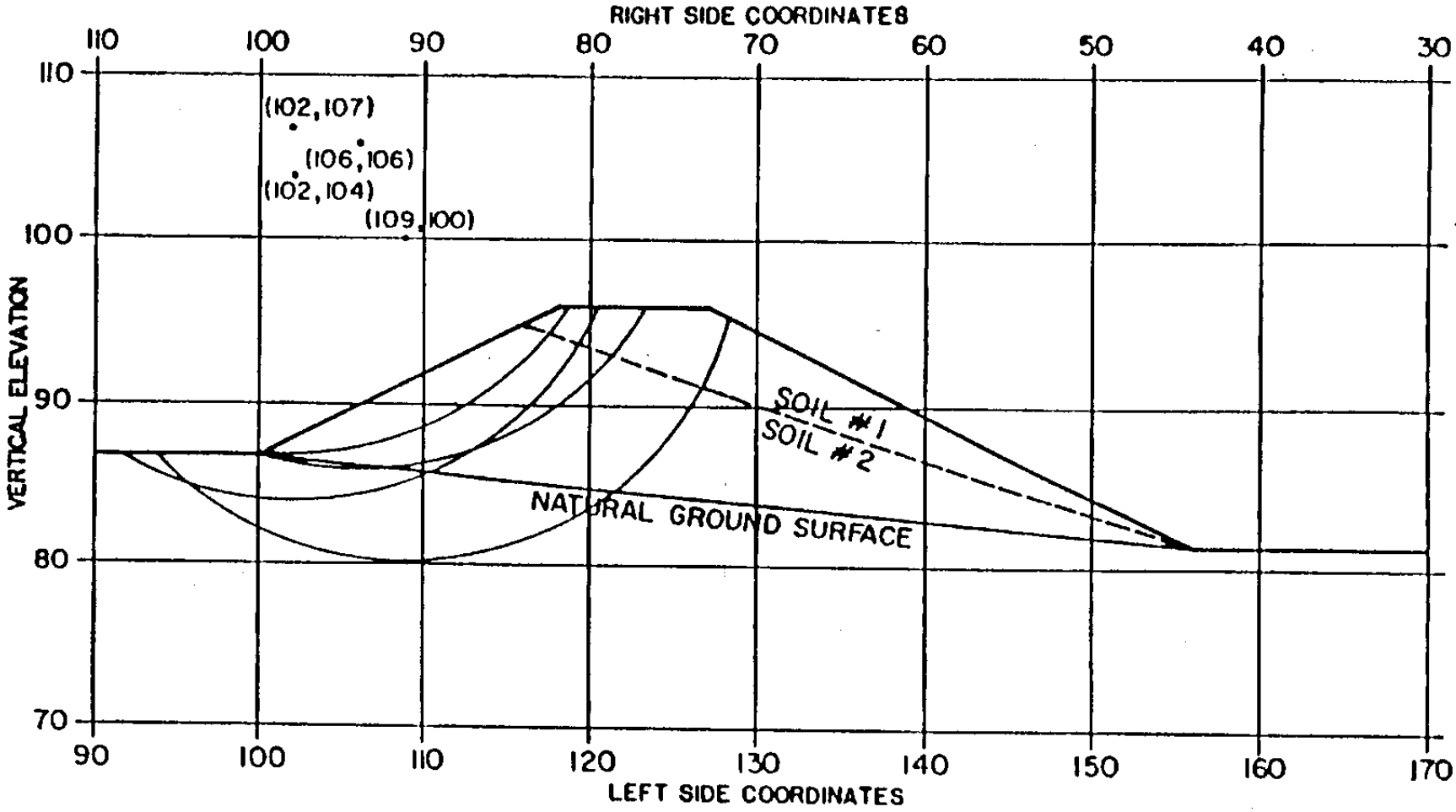
CO-OP MINING COMPANY

SCALE 1" = 10'

HORROCKS CARILLO ENGINEERS

BEAR CREEK CANYON MINE - SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 20'

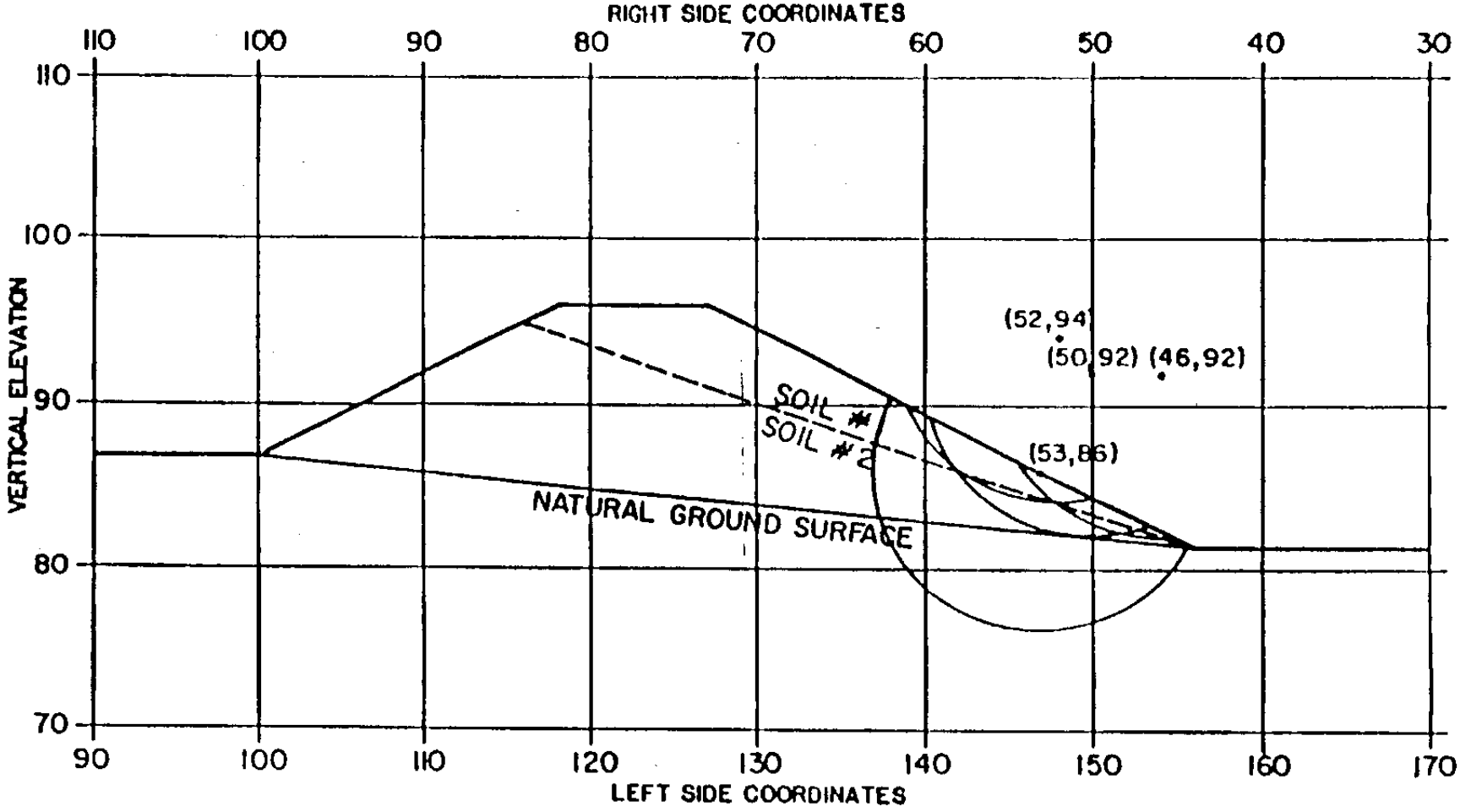
CO-OP MINING COMPANY

SCALE 1" = 10'

HORROCKS CARCILLO ENGINEERS

BEAR CREEK CANYON MINE - SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



CO-OP MINING COMPANY

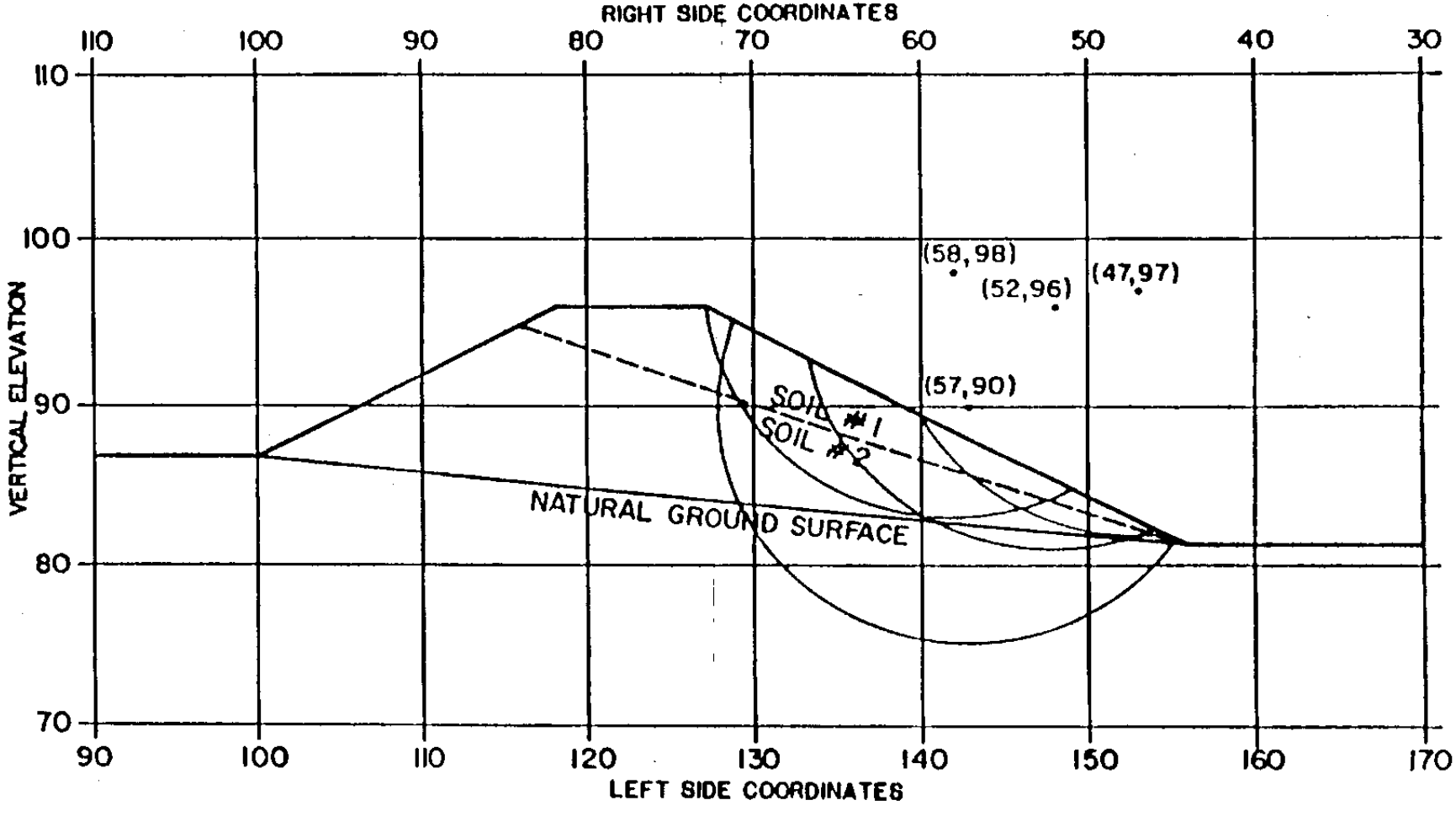
RADIUS = 10'

SCALE 1" = 10'

HORROCKS CAROLLO ENGINEERS

BEAR CREEK CANYON MINE - SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



CO-OP MINING COMPANY

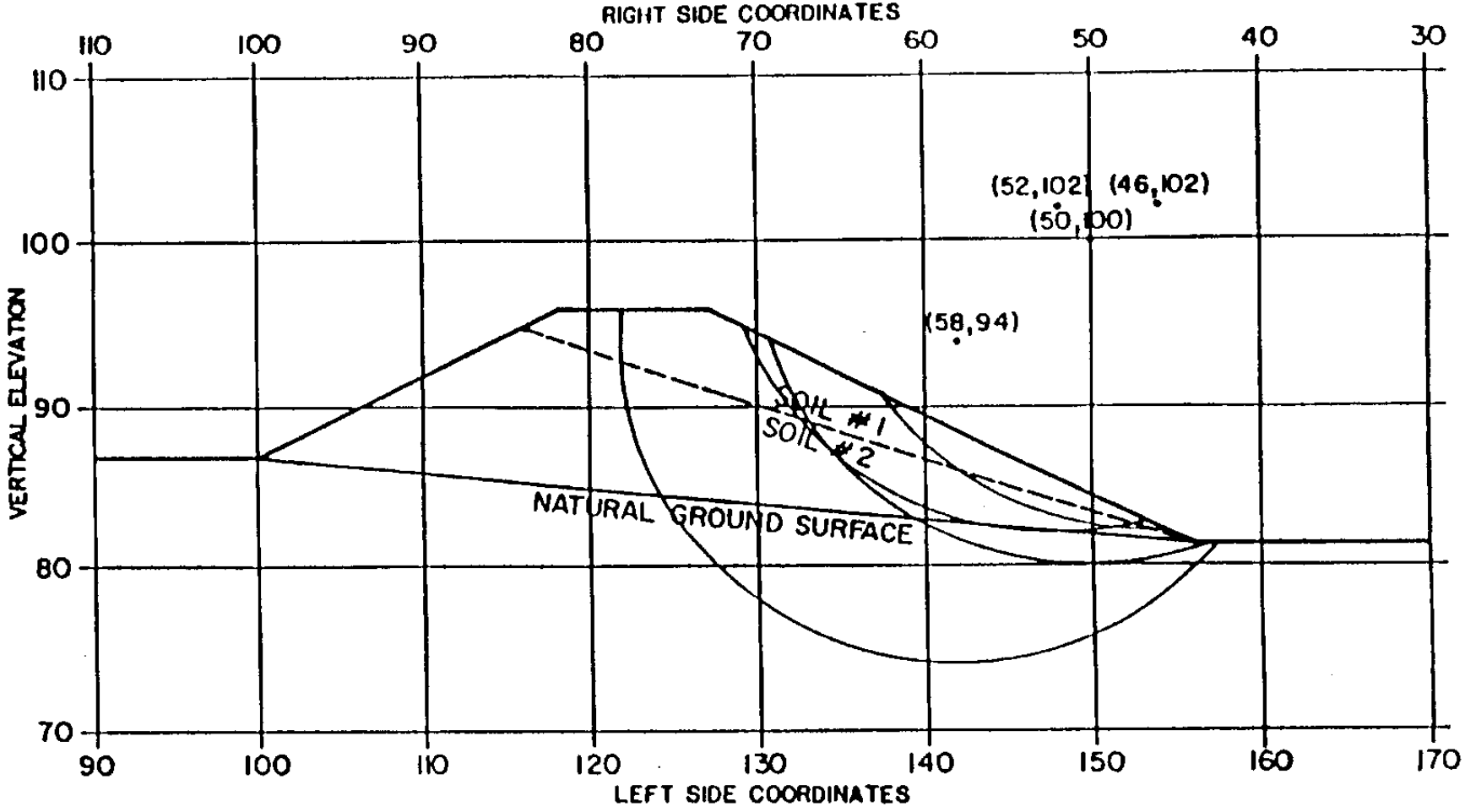
RADIUS = 15'

SCALE 1" = 10'

HORROCKS CARDILLO ENGINEERS

BEAR CREEK CANYON MINE - SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



CO-OP MINING COMPANY

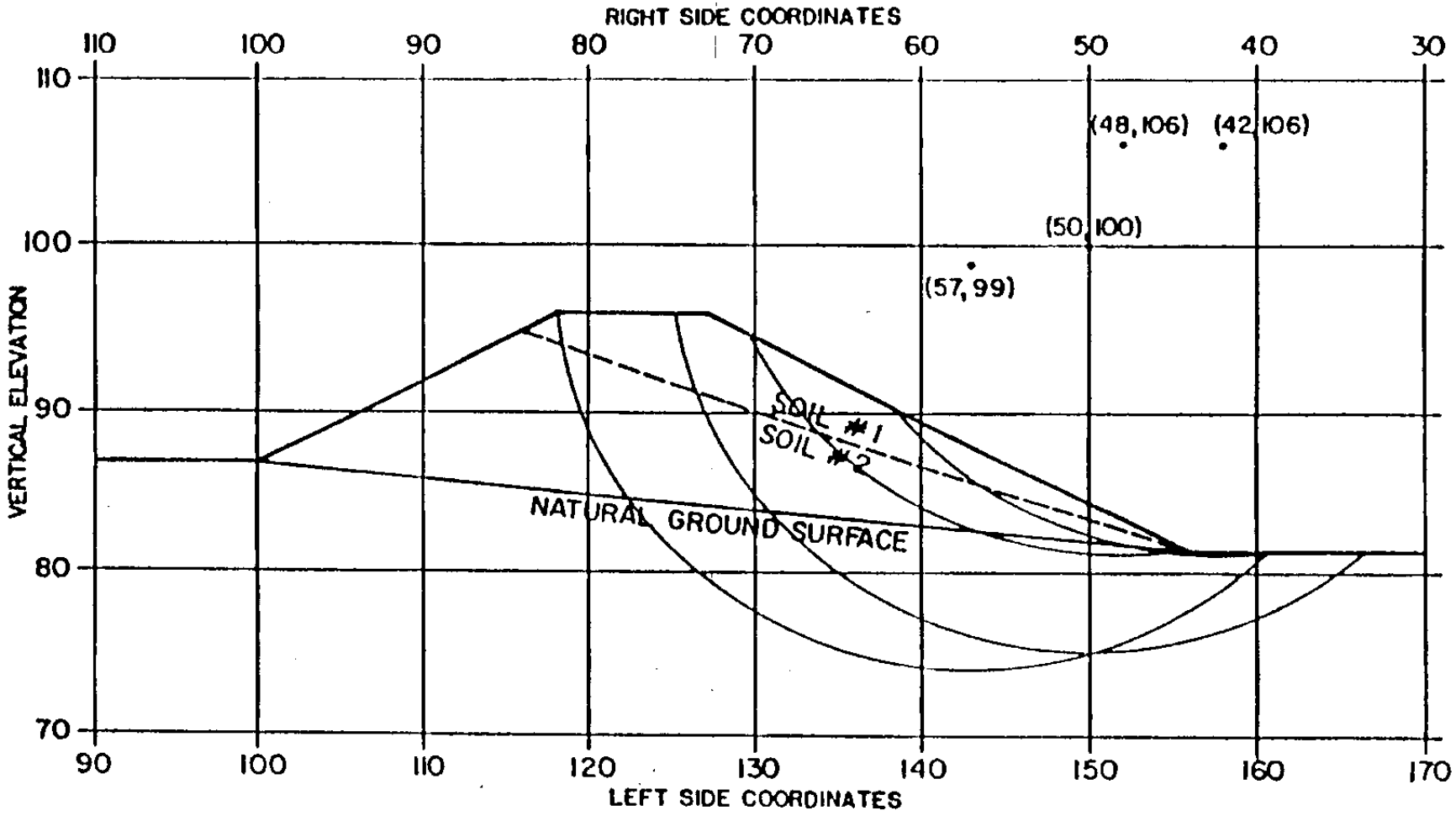
RADIUS = 20'

SCALE 1" = 10'

NORROCKS CAROLLO ENGINEERS

BEAR CREEK CANYON MINE - SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 25'

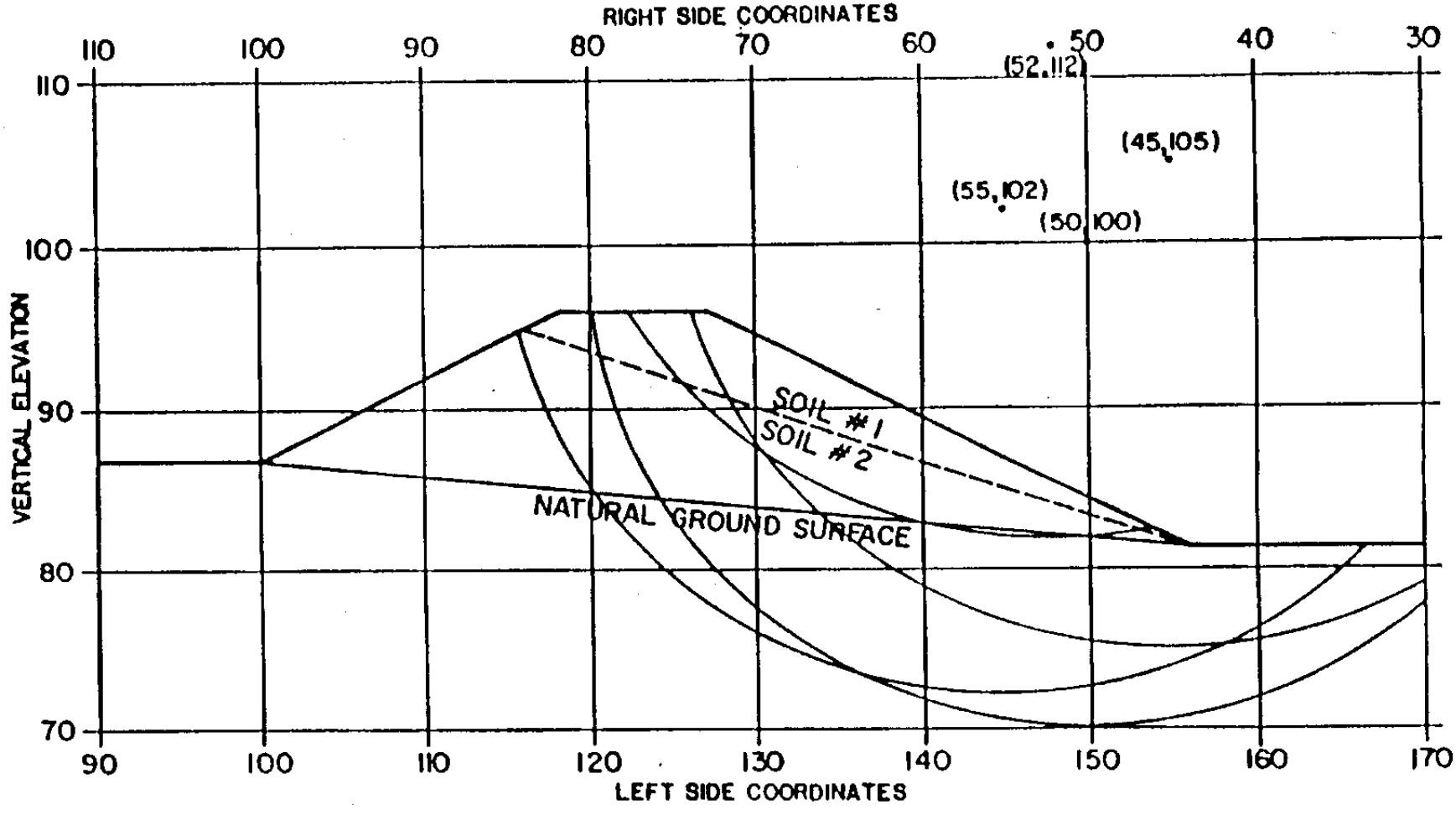
CO-OP MINING COMPANY

SCALE 1" = 10'

HORROCKS CARULLO ENGINEERS

BEAR CREEK CANYON MINE - SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



CO-OP MINING COMPANY

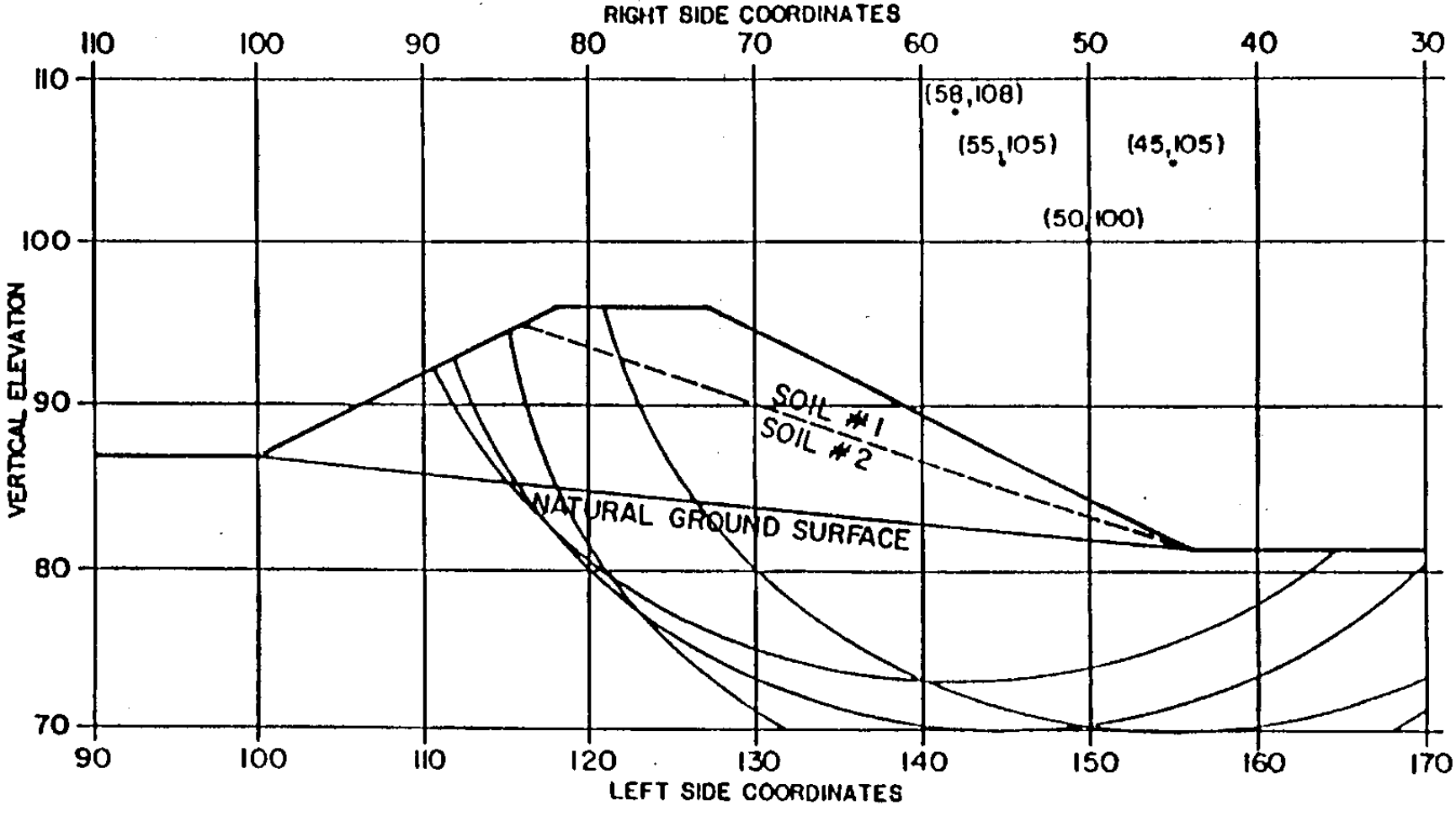
RADIUS = 30'

SCALE 1" = 10'

HORROCKS CARCILLO ENGINEERS

BEAR CREEK CANYON MINE - SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



CO-OP MINING COMPANY

RADIUS = 35'

SCALE 1" = 10'

HORROCKS CARILLO ENGINEERS

"SLOPE"

A slope stability program utilizing the simplified or "modified Bishop" method.

The program was written by John P. Cross, P.E., Processing Manager of STS Consultants, Northbrook, Illinois. This program was printed in the October 1982 issue of "CIVIL ENGINEERING."

This version was copied from "CIVIL ENGINEERING" and edited for the Hewlett-Packard 9845 desk-top computer by Horrocks Engineers in March 1983. The format for the input and the output was changed from the original version, however, the program itself was not changed.

HORROCKS ENGINEERS
ONE WEST MAIN STREET
AMERICAN FORK, UTAH 83003
TELEPHONE (801)756-7628

```
 42    OPTION BASE 1
 44    OVERLAP
 46    PRINTER IS 16
 48    PRINT "SLOPE STABILITY ANALYSIS"
 50    DIM P(50,2),L(50,3),S2(5,4),A(50),F(50,7),Z(50,4),H$[80],Sbit$(0:1)[3]
 52    INTEGER Logo(2)
 54    Sbit$(1)=" NO"
 56    Sbit$(0)="YES"
 58    S9=10
 60    J6=0
 62    OUTPUT 5;"R"
 64    ENTER 5;M,D,Time$
 66    Date$=VAL$(M)&"/"&VAL$(D)&"/83"
 68    PRINTER IS 0
 70    PRINT "",LIN(4),TAB(80-LEN(Date$));Date$,LIN(0);
 72    GOSUB Logo    ! PRINT HORROCKS ENGINEERS' LOGO
 74    PRINT LIN(5),TAB(28),"SLOPE STABILITY ANALYSIS",LIN(2),TAB(38),"for",LIN(2
);


*** INPUT OF PROGRAM VARIABLES ***

 78    INPUT "ENTER THE DATA FILE NAME",File$
 79    INPUT "ENTER THE PROJECT NUMBER",Pn$
 82    INPUT "ENTER THE USER'S INITIALS",User$
186    LINK File$,5000
190    READ H$
191    PRINT TAB(40-LEN(H$)/2);H$
195    PRINT LIN(36),TAB(30),"DATA FILE: "&CHR$(34)&File$&CHR$(34),LIN(1)
200    PRINT TAB(25),"PROJECT NUMBER: "&Pn$,LIN(1)
201    PRINT TAB(37),"by: "&User$
203    PRINTER IS 16
210    READ S0
211    IF S0=0 THEN 270
213    READ S6
215    READ S7
218    READ W0
290    READ E1
310    READ P1
311    PRINTER IS 16
315    PRINT "POINT      X-ORD       Y-ORD"
320    FOR I=1 TO P1
331      PRINT SPA(2);I;
```

```
332     IMAGE 3X,2(4D.3D,2X)
350     READ P(I,1),P(I,2)
371     PRINT USING 332;P(I,1),P(I,2)
380   NEXT I
400   READ L1
401   PRINT LIN(1),"LINE    FROM       TO    SOIL BENEATH"
402   IMAGE 3X,2(4D,3X),2X,2D
410   FOR I=1 TO L1
421     PRINT I;
440     READ L(I,1),L(I,2),L(I,3)
480     PRINT USING 402;L(I,1),L(I,2),L(I,3)
490   NEXT I
510   READ S1
511   PRINT LIN(1),"SOIL   UNIT WEIGHT  COHESION    "&CHR$(210)&"   SATURATION"
512   IMAGE 3X,4D.DD,2X,9D,3X,3D,3X,3A
520   FOR I=1 TO S1
531     PRINT I;
550     READ S2(I,1),S2(I,2),S2(I,3),S2(I,4)
610     PRINT USING 512;S2(I,1),S2(I,2),S2(I,3),Sbit$(S2(I,4))
620   NEXT I


*** CIRCLE DEFINITION  ***

640   F9=0
641   PRINTER IS 16
650   PRINT "CIRCLE DEFINITION"
660   INPUT "ENTER THE X-ORD, Y-ORD, AND RADIUS OF THE FAIL SURFACE  FORMAT X,Y,
R",X,Y,R


*** CHECK TO SEE IF CIRCLE EXCEEDS TOP LINE END POINTS ***

730   U1=P1
740   FOR I=2 TO P1
750     IF (P(I,1)<P(I-1,1)) AND (U1=P1) THEN 770
760     GOTO 780
770     U1=I-1
780   NEXT I
790   J1=R*R-(P(1,2)-Y)^2
800   J2=R*R-(P(U1,2)-Y)^2
810   IF J1<=0 THEN 830
820   IF (J1>0) AND (P(1,1)>X-SQR(J1)) THEN 860
830   IF J2<=0 THEN 850
840   IF (J2>0) AND (P(U1,1)<X+SQR(J2)) THEN 860
850   GOTO 880
860   DISP "CIRCLE EXCEEDS TOP LINE END POINTS";
870   GOTO 4380


*** DEFINE INTERSECTION OF CIRCLE WITH LINES ***

890   FOR I=1 TO L1
900     X1=P(L(I,1),1)
910     Y1=P(L(I,1),2)
920     X2=P(L(I,2),1)
930     Y2=P(L(I,2),2)
940     IF X2=X1 THEN 960
950     GOTO 970
960     S=9.99E18
970     IF X2<>X1 THEN 990
980     GOTO 1000
990     S=(Y2-Y1)/(X2-X1)
```

```
1010    C1=X1-Y1/S
1020    C2=1/S^2+1
1030    C3=2*C1/S-2*X/S-2*Y
1040    C4=C1^2-2*X*C1+X^2+Y^2-R^2
1050    C5=C3^2-4*C2*C4
1060    IF C5<0 THEN 1080
1070    GOTO 1090
1080    Z(I,1)=0
1090    IF C5<0 THEN 1630
1100    Q1=(-C3+SQR(C5))/(2*C2)
1110    Q2=(-C3-SQR(C5))/(2*C2)
1120    Q3=Q1/S+C1
1130    Q4=Q2/S+C1
1140    GOTO 1240
1150    C5=R^2-(Y-Y1)^2
1160    IF C5<0 THEN 1180
1170    GOTO 1190
1180    Z(I,1)=0
1190    IF C5<0 THEN 1630
1200    Q3=X+SQR(C5)
1210    Q4=X-SQR(C5)
1220    Q1=Y1
1230    Q2=Y1
1240    J1=0
1250    J2=0
1260    IF (ABS(S)<=9.99E9) AND (Q3>=X1) AND (Q3<=X2) THEN 1280
1270    GOTO 1290
1280    J1=1
1290    IF (ABS(S)<=9.99E9) AND (Q4>=X1) AND (Q4<=X2) THEN 1310
1300    GOTO 1320
1310    J2=1
 320    IF (S<-9.99E9) AND (Q1>=Y2) AND (Q1<=Y1) THEN 1340
1330    GOTO 1350
1340    J1=1
1350    IF (S<-9.99E9) AND (Q2>=Y2) AND (Q2<=Y1) THEN 1370
1360    GOTO 1380
1370    J2=1
1380    IF (S>9.99E9) AND (Q1>=Y1) AND (Q1<=Y2) THEN 1400
1390    GOTO 1410
1400    J1=1
1410    IF (S>9.99E9) AND (Q2>=Y1) AND (Q2<=Y2) THEN 1430
1420    GOTO 1440
1430    J2=1
1440    Z(I,1)=J1+J2
1450    IF J1=1 THEN 1470
1460    GOTO 1480
1470    Z(I,2)=Q3
1480    IF J1=1 THEN 1500
1490    GOTO 1510
1500    Z(I,3)=Q1
1510    IF (J1=0) AND (J2=1) THEN 1530
1520    GOTO 1540
1530    Z(I,2)=Q4
1540    IF (J1=0) AND (J2=1) THEN 1560
1550    GOTO 1570
1560    Z(I,3)=Q2
1570    IF (J1=1) AND (J2=1) THEN 1590
 580    GOTO 1600
 590    Z(I,4)=Q4
 600    IF (J1=1) AND (J2=1) THEN 1620
 610    GOTO 1630
1620    Z(I,3)=Q2
1630  NEXT I
1640  X4=0
1650  X5=9.99E28
1660  I1=1
```

```
2270  FOR I=1 TO Q1-1
2280    Q3=A(I+1)-A(I)
2290    Q4=INT(Q3/Q2)+1
2300    C1=Q3/Q4
2310    C2=A(I)
2320    FOR J=1 TO Q4
2330      IF J<Q4 THEN 2350
2340      GOTO 2360
2350      I1=I1+1
2360      IF J<Q4 THEN 2380
2370      GOTO 2390
2380      A(I1)=C2+C1
2390      IF J<Q4 THEN 2410
2400      GOTO 2420
2410      C2=C2+C1
2420    NEXT J
2430  NEXT I
2440  FOR I=1 TO I1
2450    FOR J=1 TO I1-1
2460      IF A(J+1)>A(J) THEN 2500
2470      J1=A(J+1)
2480      A(J+1)=A(J)
2490      A(J)=J1
2500    NEXT J
2510  NEXT I


*** DEFINE SOIL PARAMETERS FOR EACH SLICE ***

2530  F1=I1-1
2540  FOR I=1 TO F1
2550    F(I,4)=A(I+1)-A(I)
2560    X6=F(I,4)
2570    F(I,7)=(A(I+1)+A(I))/2
2580    X3=F(I,7)
2590    Y1=Y-SQR(R^2-(A(I)-X)^2)
2600    Y2=Y-SQR(R^2-(A(I+1)-X)^2)
2610    A5=ATN(ABS(Y2-Y1)/F(I,4))
2620    IF Y2<Y1 THEN 2640
2630    GOTO 2650
2640    A5=-A5
2650    F(I,2)=A5
2660    IF A5=0 THEN 2680
2670    GOTO 2690
2680    F(I,2)=1.0E-5
2690    Y3=Y-SQR(R^2-(X3-X)^2)
2700    I4=0
2710    FOR J=1 TO L1
2720      L5=L(J,1)
2730      L6=L(J,2)
2740      IF (P(L5,2)<=Y3) AND (P(L6,2)<=Y3) THEN 2840
2750      IF (P(L5,1)<X3) AND (P(L6,1)<X3) THEN 2840
2760      IF (P(L5,1)>X3) AND (P(L6,1)>X3) THEN 2840
2770      Y6=P(L5,2)+(P(L5,2)-P(L6,2))/(P(L5,1)-P(L6,1))*(X3-P(L5,1))
2780      IF Y6<=Y3 THEN 2840
2790      I4=I4+1
2800      Z(I4,1)=Y6
2810      Z(I4,2)=L(J,3)
2820      W=0
2830      E=0
2840    NEXT J
2850    IF I4=1 THEN 2970
2860    FOR J=1 TO I4
2870      FOR J1=1 TO I4-1
2880        IF Z(J1,1)>=Z(J1+1,1) THEN 2950
```

```
2900        L6=Z(J1,2)
2910        Z(J1,1)=Z(J1+1,1)
2920        Z(J1,2)=Z(J1+1,2)
2930        Z(J1+1,1)=L5
2940        Z(J1+1,2)=L6
2950      NEXT J1
2960    NEXT J
2970    I4=I4+1
2980    Z(I4,1)=Y3
2990    FOR J1=1 TO I4-1
3000      IF (I=1) AND (J1=1) AND (X3)=S6) THEN 3020
3010      GOTO 3030
3020      I6=S0-Y1
3030      IF (I=F1) AND (J1=1) AND (X3)=S6) AND (X3(=S7) THEN 3050
3040      GOTO 3060
3050      J6=S0-Y2
3060      W=W+(Z(J1,1)-Z(J1+1,1))*X6*S2(Z(J1,2),1)
3070      IF (Z(J1,1)<S0) AND (X3)=S6) AND (X3(=S7) THEN 3090
3080      GOTO 3100
3090      W=W+(S0-Z(J1,1))*X6*W0
3100      IF S2(Z(J1,2),4)>.95 THEN 3120
3110      GOTO 3130
3120      E4=S2(Z(J1,2),1)
3130      IF S2(Z(J1,2),4)<.95 THEN 3150
3140      GOTO 3160
3150      E4=S2(Z(J1,2),1)-W0
3160      E=E+(Z(J1,1)-Z(J1+1,1))*X6*E4
3170    NEXT J1
3180    F(I,1)=W
3190    F(I,5)=E
3200    F(I,3)=S2(Z(I4-1,2),2)
3210    F(I,6)=2*PI*(S2(Z(I4-1,2),3)/360)
3220  NEXT I
3221  NORMAL
3230  IF F9=0 THEN 3360
3240  PRINT USING 3250;CHR$(210)
3250  IMAGE "SLICE   WEIGHT   INCLINATION   COHESION   WIDTH   EFF WEIGHT   *A
      X"
3280  O=360/(2*PI)
3290  FOR I=1 TO F1
3300    PRINT USING 3320;I,F(I,1),F(I,2)*O,F(I,3),F(I,4),F(I,5),F(I,6)*O,F(I,7)
3320    IMAGE 3D,10D.D,7D.D,12D,9D.D,11D.D,7D,7D.D
3340  NEXT I
3350  PRINT
3360  D=0
3361  PRINTER IS 0
3370  FOR I=1 TO F1
3380    D=D+F(I,1)*SIN(ABS(F(I,2)))*(F(I,2)/ABS(F(I,2)))
3390    D=D+E1*F(I,1)*COS(ABS(F(I,2)))
3400  NEXT I
3410  IF I6>0 THEN 3430
3420  GOTO 3440
3430  I7=W0*I6*I6*(R-I6/3)/(2*R)
3440  IF I6>0 THEN 3460
3450  GOTO 3470
3460  D=D-SGN(D)*I7
3470  IF (I6>0) AND (F9=1) THEN 3490
3480  GOTO 3510
3490  PRINT USING 3500;I7
3500  IMAGE "DRIVING FORCE COUNTER BALANCE OF",10D.2D
3510  IF J6>0 THEN 3530
3520  GOTO 3540
3530  I7=W0*J6*J6*(R-J6/3)/(2*R)
3540  IF J6>0 THEN 3560
3550  GOTO 3570
3560  D=D+SGN(D)*I7
```

```
3580  GOTO 3610
3590  PRINT USING 3600;I7
3600  IMAGE "DRIVING FORCE INCREASE OF",10D.2D


*** ITERATIVE SOLUTION FOR FACTOR OF SAFETY ***

3620  F0=1
3630  R4=0
3640  I6=0
3650  FOR I=1 TO P1
3660    R1=F(I,3)*F(I,4)+F(I,5)*TAN(F(I,6))
3670    R2=1/COS(ABS(F(I,2)))
3680    R3=1+TAN(F(I,6))*TAN(F(I,2))/F0
3690    R4=R4+R1*(R2/R3)
3700  NEXT I
3710  F2=R4/D
3720  I6=I6+1
3730  IF F9=1 THEN 3750
3740  GOTO 3820
3750  IF I6=1 THEN 3770
3760  GOTO 3800
3770  PRINT
3780  PRINT USING 3790
3790  IMAGE "ITERATION",11X,"INITIAL",10X,"CALCULATED"
3800  PRINT USING 3810;I6,F0,F2
3810  IMAGE 3X,3D,13X,3D.4D,12X,3D.4D
3820  IF I6>10 THEN 3840
3830  GOTO 3850
3840  PRINT "WILL NOT CLOSE"
3850  IF I6>10 THEN 3970
3860  IF ABS(ABS(F0)-ABS(F2))<.005 THEN 3900
3870  F0=ABS(F2)
3880  R4=0
3890  GOTO 3650
3900 !
3901  IF NOT F9 THEN
3902    PRINTER IS 16
3903  ELSE
3904    PRINTER IS 0
3905  END IF
3910  PRINT
3920  PRINT USING 3930;F2,X,Y,R
3930  IMAGE "FACTOR OF SAFETY= ",5D.2D,"  AT X= ",4D," Y= ",4D, " R= ",4D
3940  PRINT USING 3950;E1
3950  IMAGE "EARTHQUAKE= ",2D.2D
3951  IF F9 THEN 4380
3960  PRINT
3961  A$=""
3970  INPUT "DO YOU WISH A FORMAL PRINTOUT (Y/N)",A$
3990  IF UPC$(A$[1,1])="N" THEN 4320
3991  PRINTER IS 0
4030  IMAGE @"WATER UNIT WEIGHT=",3D.2D
4040  PRINT USING 4030;W0
4041  IF S0 THEN
4050    PRINT
4060    IMAGE "SUBMERGENCE AT "3D.2D,"  FROM  ",3D.1D,"  TO  ",3D.1D
 070    PRINT USING 4060;S0,S6,S7
  71  END IF
 080  PRINT
 090  PRINT " POINT   X-ORD     Y-ORD"
4100  IMAGE 4D,7D.2D,7D.2D
4110  FOR I=1 TO P1
4120    PRINT USING 4100;I,P(I,1),P(I,2)
4130  NEXT I
4140  PRINT
```

```
4150  PRINT "      LINE     LEFT     RIGHT      ANGLE"
4160  IMAGE 4(5D,3X)
4170  FOR I=1 TO L1
4180    PRINT USING 4160;I,L(I,1),L(I,2),L(I,3)
4190  NEXT I
4200  PRINT
4210  PRINT "SOIL        UNIT WEIGHT        COHESION      "&CHR$(210)&"      SATURAT
ED"
4220  IMAGE 3D,15D,17D,9D,7X,3A
4230  FOR I=1 TO S1
4240    PRINT USING 4220;I,S2(I,1),S2(I,2),S2(I,3),Sbit$(S2(I,4))
4250  NEXT I
4260  PRINT
4270  PRINT "CIRCLE   X-ORD     Y-ORD   RADIUS  FACTOR OF SAFETY"
4280  IMAGE 12D.D,7D.D,7D.D,8D.2D
4290  PRINT USING 4280;X,Y,R,F2
4300  PRINT
4310  PRINT
4311  A$=""
4320  INPUT "DO YOU WISH A DIAGNOSTIC RUN (Y/N)",A$
4340  IF UPC$(A$[1,1])="N" THEN 4370
4360  F9=1
4370  IF UPC$(A$[1,1])<>"N" THEN 720
4371  A$=""
4380  INPUT "DO YOU WANT TO CONTINUE (Y/N)",A$
4400  IF UPC$(A$[1,1])<>"N" THEN 630
4401  DISP " FINISHED "
4410  STOP
4520 Logo:PLOTTER IS 13,"GRAPHICS"
4530  GRAPHICS
4540  SCALE 0,559,0,454
4550  LORG 2
4560  FOR I=0 TO 5
4570    Logo(1)=-2175
4580    Logo(2)=-4352
4590    R=454-I
4600    GLOAD Logo(*),0,R
4610  NEXT I
4620  FOR I=6 TO 14
4630    Logo(1)=-2115
4640    Logo(2)=-4352
4650    R=454-I
4660    GLOAD Logo(*),0,R
4670  NEXT I
4680  FOR I=15 TO 21
4690    Logo(1)=-2175
4700    Logo(2)=-4352
4710    R=454-I
4720    GLOAD Logo(*),0,R
4730  NEXT I
4740  CSIZE 15/4.54,9/15
4750  MOVE 27,458
4760  LABEL "HORROCKS"
4770  MOVE 27,437
4780  CSIZE 15/4.54,8/15
4790  LABEL "ENGINEERS"
4800  DUMP GRAPHICS 430,454
4810  GCLEAR
 820  EXIT GRAPHICS
 830  RETURN
```

Slope stability program

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FOR NATURAL or man-made slopes, the index of stability with respect to a sudden failure is known as the safety factor of the slope. The safety factor may be defined as the ratio of the potential resisting forces to the drive forces tending to cause movement. A slope on the verge of failure would have a safety factor of 1.0. The analysis of slope stability is, therefore, the analytical procedure of determining the most critical, i.e., the lowest, factor of safety of given or proposed slopes.

Manual methods of slope stability analysis were developed prior to the advent of the electronic computer. These approaches resulted in high analysis costs and conservative slope configurations. Repetitive calculations lended themselves to computerized methods and numerous programs exist that have been written for large computer systems to perform slope stability analysis according to a number of theoretical methods.

The simplified or modified Bishop method is reasonably accurate for most purposes where the slope under analysis can be assumed to fail along a circular failure surface. The factor of safety is defined as the ratio of the resisting moments to driving moments around the center of the failure arc. Initially, a cross-section of the slope is drawn detailing soil strata and piezometric surfaces. A center point is then chosen from which an arc is taken through the cross-section. This arc represents the failure surface under evaluation. This failure zone is broken down into a series of slices which can be individually evaluated for their weight and strength characteristics. An illustration of a slope cross-section being defined by a series of slices is shown in Figure 1.

The forces acting on each slice are illustrated in Figure 1, where ΔX is the width of the slice, W is the weight of the slice, T is the force acting along the failure surface at the bottom of the slice, N is the effective force acting normally to the base of the slice and θ is the inclination of the failure surface or slice base. The factor of safety is defined as:

$$F = \frac{\sum \dfrac{(C\,\Delta X + N \tan \Phi) \sec \theta}{1 + \dfrac{\tan \Phi \tan \theta}{F}}}{\sum W \sin \theta}$$

Where C is the cohesion, Φ is the friction angle and the summation occurs over each slice of the failure zone. As the factor of safety, F, occurs on both sides of the equation. An interactive solution where F is initially estimated and then back substituted until the calculated F and estimated F close within a specified tolerance.

The equation can be modified to handle two additional conditions by adding additional factors to the term defining the driving force. These two conditions are standing pools, i.e., submergence of a portion of the slope, and earthquake loading. For submergence, the weight of water acting above the slice is added to the weight of the slice itself. The total driving force is increased or decreased by the weight of water above or below the exit of the failure surface from the slope. The second condition of earthquake loading can be handled by increasing the driving force calculated for each slice by $EW\cos\theta$, where E is the earthquake loading factor. Similarly the resisting force is decreased by a decrease in the normal force due to the earthquake loading.

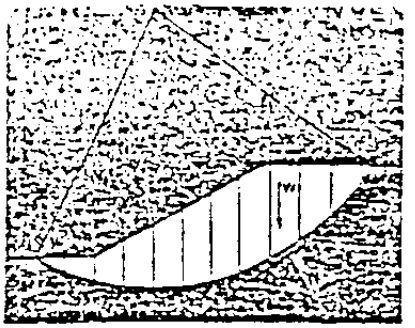

Figure 1. Failure zone is divided into slices; forces acting upon a slice are indicated.

Following the calculation of the safety factor for this arc, the center or radius of the arc is modified to generate a new failure surface. The previously mentioned procedure is again followed with a new factor of safety being deter-

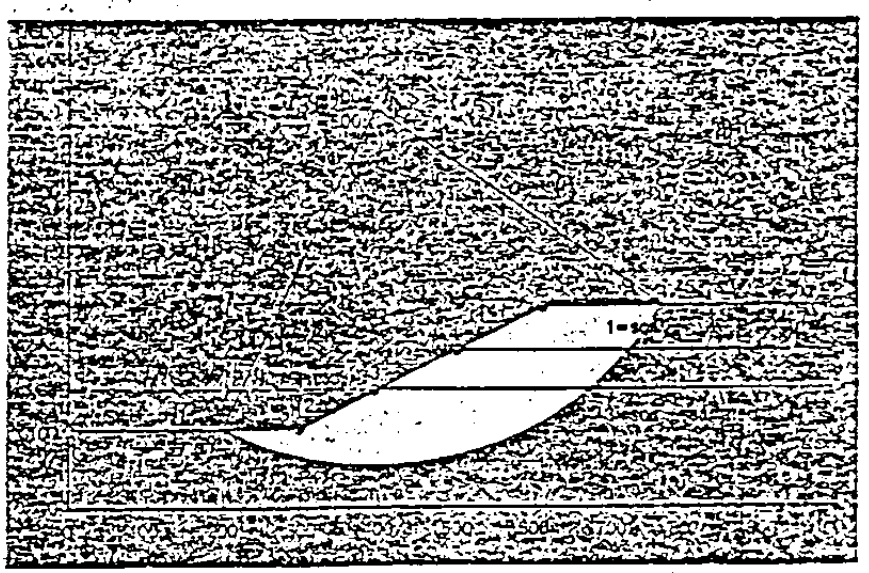

Figure 2. shows a typical cross-section and the input parameters required to define the cross-section for the program.

Table for Figure 2.

Point	X	Y	Line	Left	Right	Soil	Soil	Cohesion	Phi	Saturated
1	0	100	1	1	2	3	1	127	2000	20	No
2	300	100	2	2	3	3	2	130	1000	33	No
3	400	150	3	3	4	2	3	130	1000	33	Yes
4	500	200	4	4	5	1					
5	800	250	5	5	6	1					
6	1000	250	6	4	7	2					
7	1000	200	7	3	8	3					
8	1000	150									

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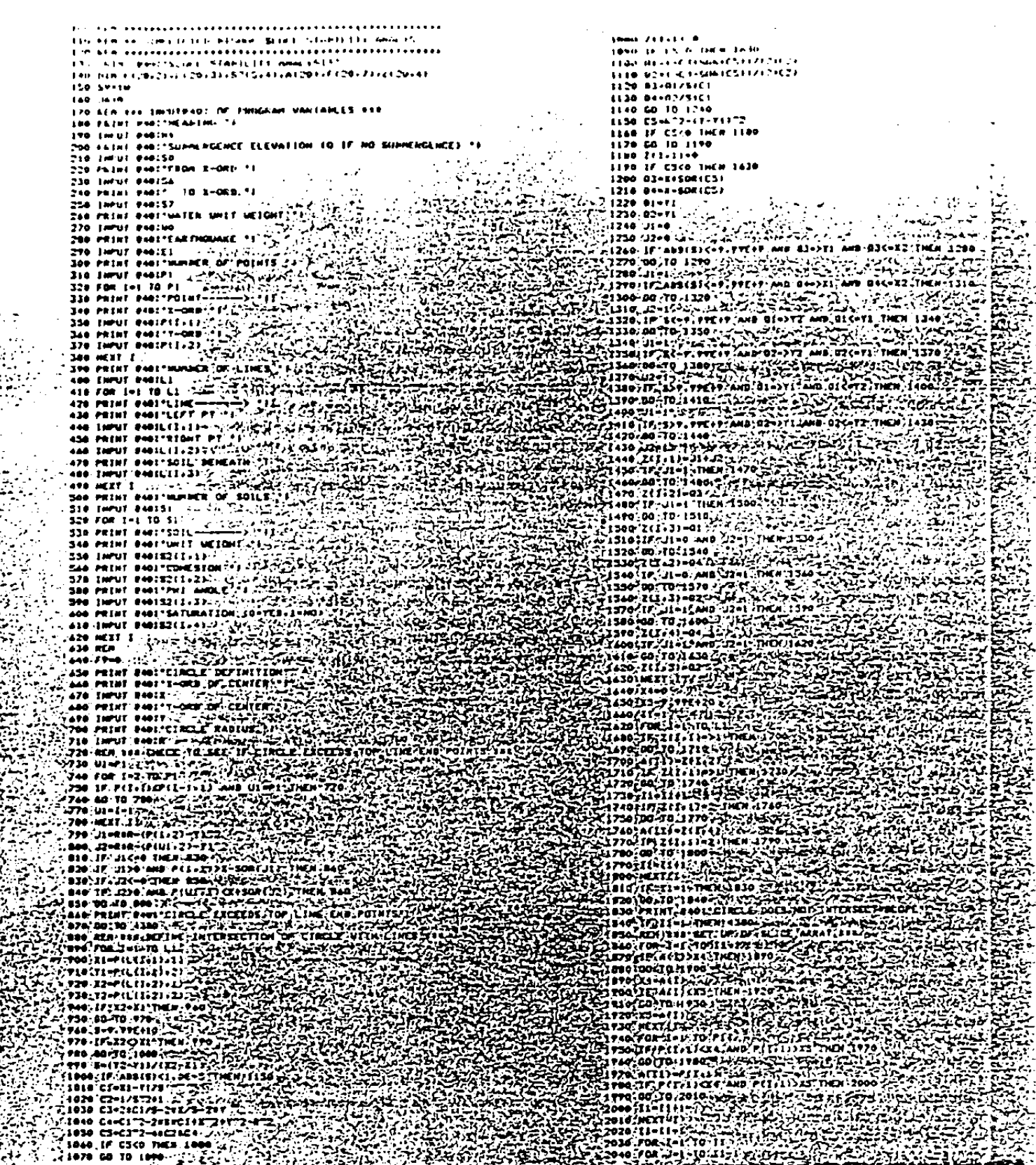

mined. This entire sequence is repeated until the failure surface for the minimum factor of safety is determined.

The program included in this article follows the same general procedure as previously defined. The program can be broken down into nine segments. Lines 100-620 are input routines for the entry of data defining the cross-section, lines 630-710 define the circle that will generate the failure surface, lines 720-860 perform a verification that the failure arc falls fully within the cross-section and lines 880-1840 define the intersection points between the line segments and the failure arc. The slice array is set up between line 1850 and 2220, with slice boundaries defined in lines 2230-2510. Lines 2520-3600 include the definition of the soil parameters for each slice and the actual iterative solution for the factor of safety occurs between lines 3610 and 3950. The remainder of the program is the formal output of the results.

The program includes a diagnostic print-out where all the slice parameters can be displayed for any given failure surface. As currently configured the program can handle models including

```
2050 IF A(J+1) A(J) THEN 2090
2060 J1=A(J+1)
2070 A(J+1)=A(J)
2080 A(J)=J1
2090 NEXT J
2100 NEXT I
2110 U1=0
2120 FOR I=1 TO I1-1
2130 IF A(I)<A(I+1) THEN 2150
2140 GO TO 2160
2150 U1=U1+1
2160 IF A(I)<A(I+1) THEN 2180
2170 GO TO 2190
2180 A(U1)=A(I)
2190 NEXT I
2200 U1=U1+1
2210 A(U1)=A(I1)
2220 I1=U1
2230 REM *** DEFINE SLICE BOUNDARIES ***
2240 B1=A(I1)-A(1)
2250 B2=B1/S9
2260 U1=I1
2270 FOR I=1 TO U1-1
2280 B3=A(I+1)-A(I)
2290 B4=INT(B3/B2)+1
2300 C1=B3/B4
2310 C2=A(I)
2320 FOR J=1 TO B4
2330 IF J<B4 THEN 2350
2340 GO TO 2360
2350 I1=I1+1
2360 IF J<B4 THEN 2380
2370 GO TO 2390
2380 A(I1)=C2+C1
2390 IF J<B4 THEN 2410
2400 GO TO 2420
2410 C2=C2+C1
2420 NEXT J
2430 NEXT I
2440 FOR I=1 TO I1
2450 FOR J=1 TO I1-I
2460 IF A(J+1)>A(J) THEN 2500
2470 J1=A(J+1)
2480 A(J+1)=A(J)
2490 A(J)=J1
2500 NEXT J
2510 NEXT I
2520 REM *** DEFINE SOIL PARAMETERS FOR EACH SLICE ***
2530 F1=I1-1
2540 FOR I=1 TO F1
2550 F(I,6)=A(I+1)-A(I)
2560 X4=F(I,6)
2570 F(I,7)=(A(I+1)+A(I))/2
2580 X3=F(I,7)
2590 Y1=Y-SQR(R^2-(A(I)-X)^2)
2600 Y2=Y-SQR(R^2-(A(I+1)-X)^2)
2610 A5=ATN(ABS(Y2-Y1)/F(I,6))
2620 IF Y2<Y1 THEN 2640
2630 GO TO 2650
2640 A5=-A5
2650 F(I,2)=A5
2660 IF A5=0 THEN 2680
2670 GO TO 2690
2680 F(I,2)=1.0E-[illegible]
2690 Y3=Y-SQR(R^2-(X3-X)^2)
2700 I4=0
2710 FOR J=1 TO L9
2720 L3=L(J,1)
2730 L4=L(J,2)
2740 IF P(L3,2)<Y3 AND P(L4,2)<Y3 THEN 2840
2750 IF P(L3,1)<X3 AND P(L4,1)<X3 THEN 2840
2760 IF P(L3,1)>X3 AND P(L4,1)>X3 THEN 2840
2770 Y4=P(L3,2)+(P(L3,2)-P(L4,2))/(P(L3,1)-P(L4,1))*(X3-P(L3,1))
2780 IF Y4<=Y3 THEN 2840
2790 I4=I4+1
2800 Z(I4,1)=Y4
2810 Z(I4,2)=L(J,3)
2820 [illegible]
2830 E=0
2840 NEXT J
2850 IF I4=0 THEN 2770
2860 FOR J=1 TO I4-1
2870 FOR J1=1 TO I4-J
2880 IF Z(J1,1)>Z(J1+1,1) THEN 2950
2890 L5=Z(J1,1)
2900 L6=Z(J1,2)
2910 Z(J1,1)=Z(J1+1,1)
2920 Z(J1,2)=Z(J1+1,2)
2930 Z(J1+1,1)=L5
2940 Z(J1+1,2)=L6
2950 NEXT J1
2960 NEXT J
2970 I4=I4+1
2980 Z(I4,1)=Y3
2990 FOR J1=1 TO I4-1
3000 IF Z=1 AND [illegible] AND X3>=S4 THEN 3020
3010 GO TO 3030
3020 I6=S0-Y1
3030 IF [illegible] AND [illegible] AND X3>=S6 AND X3<=S7 THEN 3050
3040 GO TO 3060
3050 J6=S0-Y2
3060 W=W+(Z(J1,1)-Z(J1+1,1))*X4*S2(Z(J1,2),1)
3070 IF Z(J1+1)<S8 AND X3>=S6 AND X3<=S7 THEN 3090
3080 GO TO 3100
3090 W=W+(S8-Z(J1,1))*X4*W0
3100 IF S2(Z(J1,2),4)>0.75 THEN 3120
3110 GO TO 3130
3120 C4=S2(Z(J1,2),1)
3130 IF S2(Z(J1,2),4)<0.75 THEN 3150
3140 GO TO 3160
3150 C4=S2(Z(J1,2),1)-W0
3160 E=C4*(Z(J1,1)-Z(J1+1,1))*X4*E4
3170 NEXT J1
3180 F(I,1)=W
3190 F(I,3)=E
3200 F(I,3)=S2(Z(I4-1,2),2)
3210 F(I,4)=2*PI*S2(Z(I4-1,2),3)/360
3220 NEXT I
3230 IF F9=1 THEN 3360
3240 PRINT #401 USING 3250:
3250 IMAGE "SLICE   WEIGHT    INCLINATION ",S
3260 PRINT #401: USING 3270:
3270 IMAGE " COHESION  WIDTH  EFF WEIGTH     PHI    E"
3280 Q=360/(2*PI)
3290 FOR I=1 TO F1
3300 PRINT #401: USING 3320:I,F(I,1),F(I,2)*Q,F(I,3),F(I,4),F(I,5)
3310 PRINT #401: USING 3330:F(I,6)*Q,F(I,7)
3320 IMAGE (3D,09D,1D,07D,1D,12D,07D,1D,,09D,1D),S
3330 IMAGE   7D,1D ,3D.2D
3340 NEXT I
3350 PRINT #401
3360 D=0
3370 FOR I=1 TO F1
3380 D=D+F(I,1)*SIN(ABS(F(I,2)))*(F(I,2)/ABS(F(I,2)))
3390 D=D+E1*F(I,1)*COS(ABS(F(I,2)))
3400 NEXT I
3410 IF I6>0 THEN 3430
3420 GO TO 3440
3430 I7=W0*I6*I6*(R-I6/3)/(2*R)
3440 IF I6>0 THEN 3460
3450 GO TO 3470
3460 D=D-SGN(D)*I7
3470 IF I6>0 AND F9=1 THEN 3490
3480 GO TO 3510
3490 PRINT #401 USING 3500:I7
3500 IMAGE "DRIVING FORCE COUNTER BALANCE OF",10D.2D
3510 IF J6>0 THEN 3530
3520 GO TO 3540
3530 I7=W0*J6*J6*(R-J6/3)/(2*R)
3540 IF J6>0 THEN 3560
3550 GO TO 3570
3560 D=D+SGN(D)*I7
3570 IF J6>0 AND F9=1 THEN 3590
3580 GO TO 3610
3590 PRINT #401 USING 3600:I7
3600 IMAGE "DRIVING FORCE INCREASE OF",10D.2D
3610 REM *** ITERATIVE SOLUTION FOR FACTOR OF SAFETY ***
3620 F0=1
3630 R4=0
3640 I6=0
3650 FOR I=1 TO F1
3660 R1=F(I,3)*F(I,6)+F(I,5)*TAN(F(I,4))
3670 R2=1/COS(ABS(F(I,2)))
3680 R3=1+TAN(F(I,4))*TAN(F(I,2))/F0
3690 R4=R4+R1*(R2/R3)
3700 NEXT I
3710 F2=R4/D
3720 I6=I6+1
3730 IF F9=1 THEN 3750
3740 GO TO 3820
3750 IF I6=1 THEN 3770
3760 GO TO 3800
3770 PRINT #401
3780 PRINT #401 USING 3790
3790 IMAGE 1,T,"ITERATION",10X,"INITIAL",10X,"CALCULATED"
3800 PRINT #401 USING 3810:I6,F0,F2
3810 IMAGE 3T,3D,13X,3D.4D,12X,3D.4D
3820 IF I6>10 THEN 3840
3830 GO TO 3850
3840 PRINT #401 "WILL NOT CLOSE"
3850 IF I6>10 THEN 3970
3860 IF ABS(ABS(F0)-ABS(F2))<0.005 THEN 3900
3870 F0=ABS(F2)
3880 R4=0
3890 GO TO 3650
3900 REM [illegible]
3910 PRINT #401
3920 PRINT #401 USING 3930:F2,X,Y,R
3930 IMAGE "FACTOR OF SAFETY",2D.2D,[illegible] AT X=[illegible]
3940 PRINT #401 USING 3950:E1
3950 IMAGE "EARTHQUAKE=",2D.2D
3960 PRINT #401
3970 PRINT #401 "DO YOU WISH A FORMAL PRINTOUT (Y OR N)"
3980 INPUT #401:A$
3990 IF A$="N" THEN 4320
4000 PRINT #401
4010 PRINT #401 [illegible]
4020 PRINT #401 [illegible]
4030 IMAGE "WATER UNIT WEIGHT=",3D.2D,"EARTHQUAKE=",[illegible]
4040 PRINT #401 USING 4030:W0,E1
4050 PRINT #401 [illegible]
4060 IMAGE "SUBMERGENCE AT",3D.2D,"FROM",[illegible] TO [illegible]
4070 PRINT #401 USING 4060:S0,S6,S7
4080 PRINT #401
4090 PRINT #401 "POINT  X-ORD  Y-ORD"
4100 IMAGE 4D,7D.2D,7D.2D
4110 FOR I=1 TO P1
4120 PRINT #401 USING 4100:I,P(I,1),P(I,2)
4130 NEXT I
4140 PRINT #401
4150 PRINT #401 "LINE  LEFT  RIGHT  SOIL"
4160 IMAGE 4(8D)
4170 FOR I=1 TO L1
4180 PRINT #401 USING 4160:I,L(I,1),L(I,2),L(I,3)
4190 NEXT I
4200 PRINT #401
4210 PRINT #401 "  SOIL   UNIT WEIGHT   COHESION   PHI   SATURATED"
4220 IMAGE 3D,13D,17D,7D,7D
4230 FOR I=1 TO S1
4240 PRINT #401 USING 4220:I,S2(I,1),S2(I,2),S2(I,3),S2(I,4)
4250 NEXT I
4260 PRINT #401
4270 PRINT #401 "CIRCLE   X-ORD   Y-ORD   RADIUS  FACTOR OF SAFETY"
4280 IMAGE 12D,1D,7D,1D,7D,1D,8D,2D
4290 PRINT #401 USING 4280:X,Y,R,F2
4300 PRINT #401
4310 PRINT #401
4320 PRINT #401 "DO YOU WISH A DIAGNOSTIC RUN (Y OR N)?"
4330 INPUT #401:A$
4340 IF A$="Y" THEN 4360
4350 GO TO 4370
4360 F9=1
4370 IF A$="Y" THEN 720
4380 PRINT #401 "CONTINUE (Y OR N)?"
4390 INPUT #401:A$
4400 IF A$="Y" THEN 630
```

up to 20 points, 20 lines, and 5 soil types. The minimum number of slices is set at 10, but can be changed by modifying the value of S9 at line 150 and changing the dimensioning of arrays A, F and Z.

A cross-section is drawn of the slope showing all soil strata and piezometric surfaces. Each intersect point between lines on the cross-section is numbered, with the constraint that all points along the top line must be numbered consecutively from left to right initiating with point 1. Points beneath the top line may be numbered in any order. These points are then defined with X and Y coordinates (the entire cross-section must fall in the first quadrant).

Lines are then specified by assigning line numbers for each line occurring between two end points. These lines are defined by a left point, a right point and the number of the soil type occurring beneath the line. Vertical lines are not allowed and should be modeled by offsetting the X-coordinate of one end point by a small amount, i.e., .01. Piezometric surfaces within the cross-section are treated as any other soil strata interface with saturated soil beneath and unsaturated soil above the line segment. Soil types are defined by specifying a unit weight, cohesion, phi angle and an indication of whether the soil is saturated.

Additional information that must be supplied includes the unit weigh of water, the earthquake loading factor and information defining any standing pool of water. This pool is specified by inputting the Y-coordinate of the pool elevation and the left and right X-coordinates defining the extent of the pool. The only remaining input parameters are the center coordinates and radius of the failure arc. The input can be in any consistent set of units.

Figure 2 shows a typical cross-section and the input parameters required to define the cross-section for the program. The sample execution in the box shows the typical input sequence and output formats. This result is not necessarily the minimum factor of safety for this slope, but the factor of safety for the specified failure surface. Additional runs should be made using different centers and radii until the minimum factor of safety is located.

The program presented here is the nucleus from which system specific enhancements should be made. These enhancements are not included in this version for the purpose of minimizing the size of the program presented. Particularly valuable enhancements include the ability to edit interactively, save input on a disc or tape and perform a search for the minimum factor of safety without manually inputting each circle definition. Additional enhancements could include plotting capabilities and more detailed diagnostic features.

A computerized evaluation of slope stability should never take place apart from a complete evaluation of the geophysical conditions involved. Likewise, the results should always be subjected to evaluation and interpretation based on current engineering practice and experience. ☐

Cross received his M.S. degree in civil engineering from Rose-Hulman Institute of Technology, Terre Haute, Indiana in 1972. Currently data processing manager/project engineer, Cross has been with STS (formerly Soil Testing Services) for 10 years. He holds a Master of Divinity from Trinity Evangelical Divinity School and is working on an M.B.A. at the Keller Graduate School of Management.